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THE
YOUNG LADY'S INTRODUCTION
TO
NATURAL HISTORY;

Containing an Account of the
ATMOSPHERE, LIGHT and GRAVITY,
OF THE
TERRAQUEOUS GLOBE;
OF THE
ORIGIN OF SPRINGS AND FOUNTAINS,
EARTHQUAKES AND VOLCANOS;
OF
FOSSILS, MINES AND MINERALS;
OF
VEGETABLES, ANIMALS, BEASTS, BIRDS,
FISHES, INSECTS, &c.
AS ALSO AN
INTRODUCTION TO THE KNOWLEDGE
OF THE HEAVENS;
EXPLAINING THE
MOTION, MAGNITUDE AND DISTANCES,
OF THE
PLANETS AND SATELLITES;
With some Account of the
FIXED STARS.

Extracted from the Writings of the most eminent
Authors, who have treated on those Subjects.

The Whole laid down in a plain and concise Method, in order
to render the Study of NATURAL HISTORY
easy and familiar to the FAIR.

By the EDITOR of the
YOUNG LADY'S GEOGRAPHY.

L O N D O N,

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opposite Stationers-Hall, near Ludgate-Street. 1766.

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P R E F A C E.

THE favourable reception, which the Young Lady's Geography has met with, has encouraged the editor of that work to pursue his plan of Female Education. As the former volume contained an epitome of the geography of the earth, we shall in this endeavour to give the natural history of its productions; nor shall we content ourselves with treating of those subjects only which the terraqueous globe may supply us with, but shall extend our researches as high as the far-distant regions of the planets.

Can our fair readers view the lofty canopy of the heavens, bespangled with innumerable stars, and not wish to know for what end those bright luminaries were there placed, since a little reasoning must convince them, that they were formed by the hand of the Wise Creator, for nobler purposes than solely to give light to the inhabitants of this planet! Can they observe the constant fall of hail, rain, snow, &c. and not wish to be informed of the use and origin of those vapours! Even thunder and lightening, and still more dreadful earthquakes, have all their uses and natural causes: an explanation of

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which, as well as of every other part of the works of nature, as far as the narrow bounds of our plan will permit us, is here attempted in the most easy and familiar manner.

We have begun with the natural history of the heavens, considering that as most worthy the attention of our Fair Readers. "If we look upwards to the worlds above us, (says the learned Dr. Watts) what amazing glories discover themselves to our sight! What wonders of wisdom are seen in the exact regularity of their revolutions! and I would not only recommend it to young people, but I would persuade *all*, if it were possible, to gain some degree of acquaintance with the vastness, the distances, and the motions of the planetary worlds: it gives an unknown enlargement to the understanding, and affords a divine entertainment to the soul and its better parts. With what pleasure and profit do we survey those astonishing spaces in which the planets revolve, the hugeness of their bulk, and the almost incredible swiftness of their motion: and yet all these governed and adjusted by such unerring rules, that they never mistake their way, lose a minute of their time, or change their appointed circuits, in several thousand years."

To this subject we have entirely appropriated the first book, and the five following to a philosophical survey of the works of nature,

PREFACE.

nature, viz. of the nature, use, and properties of the atmosphere, of the clouds, rain, hail, snow, thunder, and lightening; of tempests, earthquakes, and volcanos; of light and gravity; of mountains, and vallies; of the origin of springs and fountains; of vegetables, animals, birds, fishes, insects, &c. interspersed with such reflections, as cannot fail to lift up the heart with gratitude to the Wise Author of all things.

Though this treatise is intended principally for the use of the youthful fair, yet it is presumed it may not be unworthy the perusal of either sex, though advanced in the evening of life, who have, perhaps, many leisure hours on their hands, which they know not how to employ. The amusements of too many are perfectly trivial; and there are but very few, who know how either to give them a happy turn, or to mingle design with their recreations, and make virtue and pleasure go hand in hand. I have heard of those, (says an ingenious French writer) who have complained, that, during their summer residence in the country, they could find no acquaintance, books, company, or other amusement, that were any ways agreeable: however, if they would but understand how to make a right use of that instructive volume, nature, which always lies before them, they would never

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he alone, or have the least occasion to be uneasy for want of employment; and, if they would but resolve to study her with all due attention, they would find their curiosity much better gratified, and their ideas more enlarged, than by any other means whatever. — Nature is not only the most entertaining, but the most infallible library in the world.”

To conclude, the editor does not presume to arrogate to himself the honour of having started any new systems either in astronomy or philosophy, but gratefully acknowledges having borrowed every thing from the writings of the most eminent authors. If he shall appear to have collected the most curious opinions of the learned on the most important truths, and to have properly digested them, so as to render this little treatise worthy the perusal of the fair sex, he shall think those hours well employed, which he has devoted to so profitable and amusing a study.

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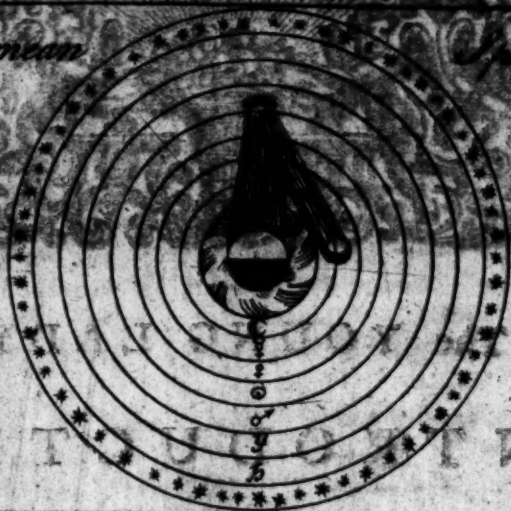
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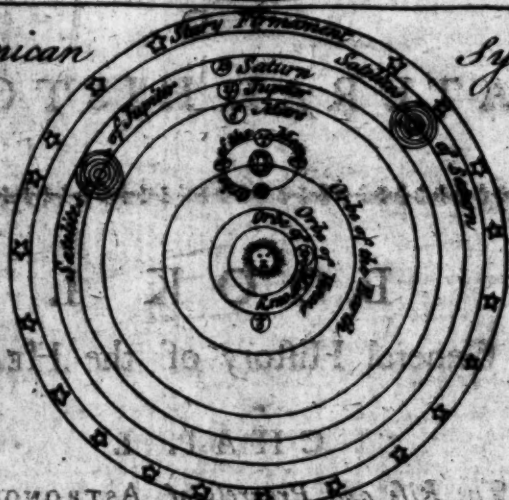
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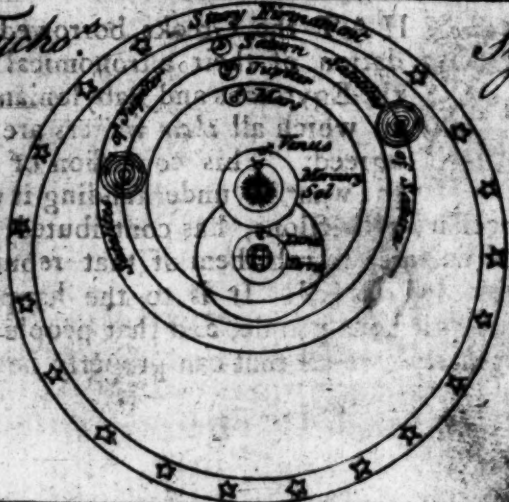
Copernican

System.



Tychonic

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The YOUNG LADY'S
INTRODUCTION
TO
NATURAL HISTORY.



BOOK I.

A General History of the HEAVENS.

CHAP. I.

The Rise and Progress of ASTRONOMY.



HAT the Greeks borrowed the foundation of their astronomical skill from the Egyptians and Babylonians, is a point in which all *their* writers are universally agreed. This concession of theirs, and the want of understanding it with proper and necessary restrictions, has contributed, among all sorts of writers, to rob them of that reputation they undoubtedly deserved. It is to the happy genius of that once glorious people, and that people alone, that we originally owe all that can properly be styled astronomy.

B

That

That mankind began very early to lift up their eyes to Heaven, and observe that beautiful canopy so richly adorned, is not at all surprising; but that these observations, before the flood at least, contained any thing more than mere curiosity, may very easily be doubted. Josephus, fond of raising the credit of his nation, will needs make the immediate descendants of Seth the original authors of astronomy. If he may be credited, they wrote too their observations upon two pillars, one of brick, and the other of stone, to preserve them secure against the destruction, which Adam, it seems, had foretold them, should, one time or other, put an end to all things. The extravagancy and inconsistency of this whole account is such, as will justly excuse the saying any thing further upon it.

The times on this side the deluge are the highest that arts and sciences of any kind can pretend to go: but here again, the Egyptians laying claim to the original invention of them (as indeed to the greatest antiquity as a nation) the same Jewish historian, keeping still the same point in view, appears ready to contest it with them. The patriarch Abraham, if he may be heard, introduced the knowledge of the heavens in Egypt: his father Terah, according to the eastern writers, to make this the more probable, was a maker of talismans, or little images, formed in some planetary hour. But, that the motion of the planets were at all known so early as this, much less their dominion, or astrological influences, so much as dreamed of, is more than can be made appear from any argument worth attending to, and may be justly looked on as one of the many romances to be met with in the historians of that part of the world.

It is not to be disputed, that the Chaldeans very early studied the heavens: they were favoured by their situation; they had an open country, and a fine air; and they were, from generation to generation, addicted to the study of the stars; but they pretended to more knowledge than they really had: mere observation must have shewn them, that the planets moved along the heavens, whilst the fixed stars retained their places, and but by the perplexity of the earth's also moving, they would undoubtedly have found out the period of their several revolutions:

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revolutions: they must also have had the same opportunity of perceiving that the comets had motion; but, when we are told of their having had the art of foretelling their appearances, and of predicting eclipses, we may know what we ought to think of the account, more especially when we see added to it, that they could predict tempests and earthquakes, which we know to be impossible.

From these people, who, doubtless, distinguished the comets and the planets from the other luminaries of heaven, and who certainly had the division of the fixed stars into constellations, (and, for aught we know, were the first that had it) the Greeks received their rudiments of astronomy; and, whatever may be boasted of by those who love to carry all knowledge back to the remotest antiquity, it is probable this, or a very little more than this, was all the Greeks learned from them.

The Greeks, we find, very early had ships; the Argonautic expedition is a proof of it; and Sir Isaac Newton supposes a great deal of the knowledge of the fixed stars to be from that period: it is certain, that persons, who were many nights out at sea, were the most likely to observe them. Towards the time of the Trojan war the Greeks, we find, were very intent upon this study; and the father of Agamemnon is celebrated by Euripides as an astronomer. The Argonautic expedition was, as some say, twelve hundred years before the birth of Christ; and we hear of Mæzus, one of the heroes concerned in it, as having invented a sphere; but we are not to conceive any great things of such an early discovery, or to suppose it any thing like what we now understand by that term.

The oldest of the Greek authors, who has mentioned the constellations, is Hesiod; and he has named only a few of them, and these very imperfectly, and in such a manner, as to prove the very names of some of them were foreign. If we allow the Pleiades, the Hyades, and the single star Arcturus, to be of Greek denomination, certainly the Orion is foreign to that people; and Sirius, whose name is from Siris, one of the denominations of the Nile, which river was ob-

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served to swell at the rising of that star, must have been delivered to them from the Egyptians.

We find Thales was the man, who first established astronomy on any tolerable footing among the Greeks; and we find it also recorded of the same Thales, that he was the first Greek, who travelled into Egypt to study the sciences. He lived between five and six hundred years before the birth of Christ; and, if we consider the time and the state of astronomy before him, we shall think very greatly of him, if we believe but a small part of what is recorded.

If there be a name more famous than that of Thales, for the improvement of astronomy, among the Greeks, it is that of Pythagoras: he lived five hundred and odd years before Christ, and was sixty or seventy years later than Thales. There is no disputing his title to the improvement of astronomy in a great degree among the Greeks; and, if we enquire into his history, we shall find that he spent a great many years in Egypt, and was famous for his good intelligence with the priests of that country, who were the people most eminent in knowledge, not only in astronomy, but in all the other sciences.

However, with all the boast that is made of the astronomy of those times, we shall have but a very moderate opinion of it, when we find one of the established doctrines to have been, that the Sun was only three times as far from the earth as the Moon: or, if we take the largest account, and give credit to those who say they made it six times as distant, still the absurdity is obvious.

Among the many celebrated astronomers, to whom the Greeks were indebted for what they knew of this science, we must not neglect to mention Eudoxus, who wrote three hundred and sixty years before Christ—Aristarchus, who immortalized himself, and worthily, by his conjectures, not to call them absolute calculations, of the earth's distance from the Sun, of the Moon's distance from the earth, and of their comparative magnitudes—Archimedes, who assigned, with a surprising accuracy for his time, the places and distances of the planets, and laid the foundation of what has

has done so much true honour to astronomy.—Hipparchus, whose steps were so closely followed by Ptolemy, that he feared to depart from them; and, indeed, much of that knowledge, which we reverence in the latter, was truly the knowledge of the former.

From Ptolemy we may date the great progress of astronomy throughout the world; for, till that time, what had been learned from the Egyptians, had been, in a great measure, confined among the Grecians. Ptolemy wrote for all mankind: his system was publicly taught every where, and his writings translated not only into Arabic, but almost all the other languages. The system of Ptolemy was looked upon as sacred truth beyond all dispute. It was long after him, however, that Europe received the true taste for the study of the heavens: it was not till almost eleven hundred years after their publication, that the works of this author were translated into Latin, and that astronomy became a study regarded by the learned in this quarter of the world; in which it has at length arrived to an height, as much above all that it reached in Greece, as the highest pitch of the Grecian knowledge was above the Egyptian. Indeed, it is only within these hundred years, or thereabouts, that the heavens have been understood; and all that was before delivered is ignorance, in comparison with what is now established, and explained among us, by the incomparable Sir Isaac Newton, and other modern writers.

CHAP. II.

Of the SOLAR SYSTEM.

IN order to explain the disposition and arrangement of the several parts of the universe, and to shew in what manner the celestial bodies move, with regard to one another, and with regard to this earth, which we inhabit, men have, from time to time, laid down certain hypotheses and systems, which they have called systems of the world. There have been several of these different in the greatest degree from one another: they began very far from truth; and as science improved, they, by degrees, came nearer and nearer to

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it, till they completed the present established system, which, there can be no reason to doubt, will last as long as that world it explains. It is indeed a little surprising to see how many different ways people have found to explain the same appearances, for they were the same to all.

Some have imagined (as it appears at first sight to the senses) that this earth we inhabit was placed in the centre of the universe, and that the Sun and stars did, in reality, perform severally their revolutions round this globe; not only the diurnal, which is from east to west; but also the general course that they all take at a longer period, and which is, on the contrary, from west to east. The first, or the diurnal motion, they supposed to be common to them all, and the latter to be peculiar to each.

Others, on the contrary, have placed the Sun in the centre of the universe; they have made that the sole immoveable body, and they have laid it down, that the planets, and this earth itself, also, made their revolutions about that body: these have understood also, that what appeared to be a diurnal revolution of all the heavenly bodies round about the earth, was no other than a motion in the earth itself, a revolution round its own axis, which it accomplishes in twenty-four hours, and in a direction contrary to the apparent motion of all these, from west to east.

The first of these opinions was the most natural for those to embrace, who judged only by appearances, as they took them at first sight; the latter could arise only from diligent enquiry, and a second judgment: the first therefore was natural to be established in the least-improved times, and the other after the cultivation of science.

We shall here, however, take notice only of the Copernican, or Solar System, being that which is retained by the most eminent mathematicians of the last and present age, as the best adapted to explain the nature and motion of the celestial masses.

The Solar System consists of the Sun, and the planets and comets moving about it.

The

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The planets are bodies which appear to us like stars; not that they are luminous bodies, that is, have light in themselves, but shine by reflecting the light of the Sun.

They are called planets from a Greek word, which signifies *wandering*; because they change their places, and do not always keep the same distance with one another, nor with the fixed stars, as the fixed stars do.

The planets are either *primary* or *secondary*.

The *primary* planets are six, viz. Mercury, Venus, the Earth, Mars, Jupiter, and Saturn.

The *secondary* planets, so called because they move round other planets, are ten, viz. the Moon, which moves about the earth; the four Moons, or satellites, which move about Jupiter; and the five Moons, which move about Saturn.

The orbits of the planets, and their respective distances from the Sun, and from one another, may be seen in the diagram of the solar system, as represented on Plate I. on which plate we have likewise given a representation of those spheres invented by Ptolemy and Tycho, which are too plain to stand in need of any explanation.

CHAP. III.

Of the Sun, the CENTRE of the UNIVERSE.

THE Sun is the first and greatest object of astronomical knowledge, and is of itself enough to stamp a value on the science to which the study of it belongs. There have not been wanting, in the less improved times, those who have erred extremely about the nature, situation, and the motions of this luminary; but its vast importance to the inhabitants of this earth, is a thing to which all eyes must be open. We see it the fountain of light and heat; we see it the parent of the seasons; day and night, summer and winter, are formed intirely by it, and all the vegetable creation are the offspring of its beams; even our own lives are not to be supported but by its influence; and, where it has least power, we find that life hardly deserves the name of a blessing. It is in the heart of man to value

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what he possesses; but, to any one who has seen a happier climate, the frozen regions seem to make life a punishment.

The earliest astronomers, Philolaus and his predecessors, declared the motion of the Sun round about the earth to be only apparent. They saw the importance and superiority of such a globe over ours, and could not suppose it formed only to give us light; but imagined its influence extended throughout much larger bounds: they therefore placed it in the centre of the universe, and supposed it fixed without any motion.

Appearances weighed more than judgment in the succeeding times. Ptolemy, long since, and, of a later time, Tycho Brahe, have made the Sun revolve round the earth. This, though it may correspond with common appearances, is absurd and idle. It were as reasonable for a young lady, who is carried along the river in a boat, to suppose the houses and churches on the shore ran by her, because she did not perceive her own motion, as to imagine so immense a body as the Sun rolled round about such a spot in the universe as this earth, because the eye, not perceiving the motion of the earth, is led to see it so. Ptolemy was very faulty in taking up a vulgar opinion in the place of that of his wise predecessors; but what shall be said of Tycho Brahe, so great a man, who yet established such a system after the time of Copernicus!

At present, all men agree with Copernicus, that the Sun is fixed in the centre of the universe, and that all the planets, of which this earth inhabited by us is one, roll round its body. This, indeed, is taking something from the importance of our world: but we should not glory at the expence of truth. It is certain, that the earth is not the great point in the system, but is one of the several orbs that roll round about the Sun.

The Sun is a spherical, luminous body. The Moon and the planets give light to us, but that is not inherent in them; they are in themselves opaque, and what light we have from them they first receive from the rays of the Sun, which are reflected to us. A look-
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ing-glass has no light in itself; but it may be so placed as to receive the rays of a candle, which we do not see, and throw them back to us: but the Sun is in itself possessed of light; it does not borrow this from any other, but, being a body of fire, it shines as such; it expands all about it to a great distance, so as to enlighten, as already observed, not only the earth, but all the planets, of which some are immensely more remote. The fixed stars, on the contrary, have, like the Sun, their light in themselves, but are at too great a distance to reflect much of that light to us.

The Sun and fixed stars (says the great Dr. Cheyne) seem to be huge, dense bodies, like the earth or planets, heated to an extraordinary degree; and their heat probably may be preserved by the greatness of their bodies, and the mutual action and re-action between their parts and the light which they emit; and their parts are kept from fuming away by their fixity, as well as by the vast weight and density of the atmosphere incumbent upon them, and powerfully compressing them, and condensing the vapours and exhalations which arise from them. The light seems to be emitted from them by the vibrating motion of their parts, after the manner we see iron, when heated to such a degree, as to be just going into fusion, by the vibrating motion of its parts, send forth, with force and violence, copious streams of liquid fire all around. Great bodies preserve their heat longest; and that perhaps in proportion to their diameters. Sir Isaac Newton has made it probable, that the comet which appeared in 1680, by approaching to the Sun in its perihelion, acquired such a degree of heat as to be fifty thousand years in cooling: whence we may guess, that, supposing the Sun and fixed stars to be only collections of dense and solid matter, like the planets, heated to a very intense degree, they may be many millions of years without losing any considerable part of their heat. Astronomers have observed a close, compact, and large atmosphere about the Sun; and there is no doubt to be made, that its body is of the same nature with the other material parts of this universe, excepting what alterations its vehement heat may produce;

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and, consequently, it is highly probable, that the Sun and fixed stars are only planets vehemently heated.

That the Sun is a body of fire, appears to the senses; but we have had a set of philosophers of late, who, right or wrong, insist on its being otherwise. The old philosophers all declared it a body of absolute fire: so Plato, Zeno, and Pythagoras, express themselves; and so, among the moderns, Kepler, Kiercher, and the greatest who have followed them: but Descartes and his followers say otherwise; they would have us believe that there is no absolute fire in the Sun, but that it is a vast globe, composed of a subtile matter, capable of exciting the sensations of light and heat. This is, indeed, subtile talking; but the best way to examine its validity, will be to examine the Sun itself. This we may do by telescopes properly prepared, and by receiving the image of the luminary into a darkened room.

The Sun is too bright for the view of the naked eye; his lustre dazzles, and takes away the power of seeing, if we attempt to look directly at him; but sometimes there are rays that render the atmosphere about us a medium through which we may see him without pain, but then not distinctly. A thin cloud answers the same purpose; and we may also view him near the horizon: but we can distinguish little from such observations; all that we see is, that the figure of the Sun is round. A piece of glass blacked with smoak, will, at any time, do the office of a cloud or a fog; and we may thus see his figure and out-line, but that is all. We see his disk throughout of one uniform colour, which varies according to the degree of blackness there is upon the glass. When we view the Sun through telescopes, we perceive the same round figure; but we see on its disk certain spots less bright than the rest, which we did not distinguish by the simple view: these spots are usually black, and have round them an edge of brown: this is a little clearer in the inner part, where it adheres to the black; on the exterior, the figure of these spots in the Sun's face is irregular, and they are not fixed and certain in their form or situation, but liable to many changes. It is a common thing,

on repeating the observation, to see a number of these spots together, at no great distance from one another, and to find that they daily change place with regard to one another; and even change in number.

These spots are yet subject to greater variations; for they are not permanent, but will disappear at times; and, if they appear again, it will be in a different form: so that it is hard to say, whether what is seen is the old spot, or is another in the same place. The time of the duration of these spots is as uncertain as their figure; but they have seldom a very long duration. The observation of those which have continued the longest, has not given them more than eight or nine weeks duration; many of them appear, and are lost again, in as many days, or in yet less time. How this is to be reconciled to Descartes's subtle matter, is not easy to say; but supposing the Sun a body of absolute fire, it is very natural to imagine that such changes will happen.

The dispute, as to the discovery of these spots in the Sun's disk, lies between Scheiner and Galileo; it was made about an hundred and fifty years ago. However that be, it was almost a necessary consequence of seeing the Sun through a telescope; for it is very rare that the disk is wholly clear of them: Scheiner says he has counted fifty of them on it at the same time; at present twenty or thirty is sometimes a common number. In this, however, there is a great deal of variety, and it is singular enough to observe it. There are some years, in which it is rare to see more than one or two at a time. We have accounts of years, in which there have been none discovered; in others, we see the numbers and extent of them both very great. It is evident, therefore, that there is no sort of regularity either in the number or figure of these appearances. They do not, however, appear always fixed in the same place, but regularly move from east to west, as seen from the earth; but, to speak of their real motion, we must suppose the point of view to be directly in the centre of the Sun, and their motion would then be from west to east, which is the true course

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course of it, and is the same with all the other motions of the heavenly bodies.

When the spots of the Sun were first observed, there was no small doubt, whether they did immediately touch and adhere to the body of the Sun, or whether they were at some small distance from it, and were a kind of planets forming a quick revolution round it, like those of the earth and the other planets; but it was soon determined, that they really were adherent to the surface of the Sun, although elevated above the general plane, and were parts of its body, and not distinct bodies moving round it.

In the observations made on the spots, it is the general rule, that those which are nearest to the centre of the disk appear largest, and those nearest to the edge smallest. This appears not only in our own observations, but in all the figures of the Sun's face, which have been drawn from those of others. It appears also, that the spots about the centre are of a kind of roundish figure, and that they lose this as they depart from it, becoming elliptic at first, and, at the last, when near the edge, so narrow, that they appear almost as straight lines. We learn two things from this appearance: first, that the body of the Sun is absolutely globular or spherical; and, secondly, that these spots are flat, or not very much elevated, but are close to its surface.

It has been supposed by many, that the Sun is naturally a solid, opaque, and irregular body, having, like this earth, hollows, plains, and mountains; and that its whole surface, with all these irregularities upon it, is covered to a certain depth with a fluid matter which is luminous; and they suppose that this fluid, being liable to motions, sometimes is collected into a quantity in some particular hollow, and consequently leaves the tops of these rocks or mountains bare, and that these, appearing above the surface of the fluid, and not having its luminous quality, form the opaque spots which we see; and they suppose a sort of froth or foam, made by the motion of the fluid round about these rocks, to occasion that nebulousity or brownness seen all round their circumference. These prominences, they say, are covered when the fluid runs back again

into

into its old place; and then some others, in other parts, are exposed by the same fluid's deserting them as it did the first. If, at any time, these spots appear again, it is not, on this principle, a wonder that they are not exactly the same in form and dimensions as at the first, for that more or less of the eminence may be thus left uncovered; but this they alledge as a very probable occasion of the same spots appearing at different times.

The supposition of the Sun being an opaque body, covered by a luminous fluid, has not been limited to these: there have been others, who, supposing the structure the same, have found another way to account for the spots. They suppose that, in this solid body of the Sun, there are volcanoes, like our *Ætna* and *Vesuvius*, which throw forth at times great quantities of matter, which thus deform the Sun with spots, rising up above the fluid surface. They suppose that this matter is, by degrees, consumed, and taken into the fluid mass, upon the surface of which it at first floats; and that, as this is a work of time, the first appearance of the effect of the burning fluid, is the making that brown circumference, or nebulosity, which we see about the edges; and that, after this, the spots, by degrees, change figure, as they are more and more consumed, till they are wholly swallowed up and disappear. This system also accounts for their often re-appearing in the same places, and in different forms; because the volcanoes may continue where they were, and, from time to time, throw up quantities of new matter, though sometimes more than at others.

Others have supposed the Sun a much more furious and turbulent quantity of matter; they imagine it to be composed throughout of a boiling fluid, but that there are, among this, certain masses of solid matter, immensely great, but of irregular figures; they suppose the vast mass of fluid to be in continual motion, and to be at times plunging these solid masses down, and at times throwing them up to the surface, and shewing more or less of their bulk.

Finally, others have determined, that the body of the Sun, being composed of a subtile and fluid matter

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in continual agitation, the fouler or thicker parts, of what kind soever, are, by that motion, separated, time after time, from the rest; and that, being thrown up to the surface, they float upon it, like the foulness of metals when melted, and by degrees, getting together in clusters, in form of scum, constitute those spots which we see on the surface: these parcels of scum, being agitated by the boiling matter underneath, must be frequently altering their shape, as we see those spots do, and move farther from, or approach nearer to, one another; and, in fine, the same agitation which threw them up, may, by degrees, dissipate them, till they are no more seen.

It is evident from the appearances of these spots, that they have either a regular and periodical motion round about the body of the Sun; or else, which is more probable, and will occasion the same appearances, that the body of the Sun itself does turn round on its own axis, and carry with it, in that motion, these spots which are fixed to, and are a part of, its surface. Reason, and the general course of nature, declare for this latter being the case; and consequently we have discovered, by the observation of these spots, that the Sun does turn round its own axis, and that the revolution is performed in twenty-seven days, or thereabouts.

To persons not accustomed to astronomical calculations, it cannot fail of being a matter of surprise, when they read, or are told, of the magnitude of this luminary, the Sun, which, from its vastly greater distance, appears to us but little larger than the Moon, which is a small and secondary planet, a satellite, or attendant on this earth. What will be the astonishment of our fair readers, if we tell them, that, when looking at the Sun, they are viewing a globe of solid and of liquid fire, (for that is probably its structure) the diameter of which is equal to an hundred diameters of the earth; whose thickness, in more plain terms, is seven hundred and ninety-three thousand miles; that its surface is equal to ten thousand times the surface of the earth, and whose solidity is a million times as great!

Let

Let us now proceed to describe the motion of this luminary. The antient astronomers observed, that, besides his apparent motion round the earth in twenty-four hours, by which he made, as they supposed, day and night, the former when he was above, the latter when he was below, the horizon of any place, (which daily or diurnal motion they supposed to be always made either in the equinoxial circle, or in some other lesser ones parallel to it, or equally distant from it; these parallel circles also they supposed to be, in the summer half-year, on the north side, and, in the winter, on the south side of the equinoxial) they took notice that, besides this diurnal motion, which appeared to be circular, the Sun had also in appearance a progressive one, forward on, in another track in the heavens, which, because they found, that when the Moon came into the very same circle there would be an eclipse of either her or the Sun, they called the ecliptic: this is that circle on the globe, which lies oblique to, and cuts or crosses the other, which is drawn exactly in the middle, between the poles, and is called the equinoxial or equator. This ecliptic circle, because they perceived that the Sun never deviated from it in his annual motion towards either pole, north or south, they called *The way of the Sun*; and they found, that in the time of our common year, he would appear to go quite round, or pass successively through all the parts of this circle.

The method in which they discovered this, was by taking notice of those stars which were at or near the edge of the horizon *before* his rising, and such as were there *after* his setting; for, when the Sun was *above* the horizon, no star at all could be seen whereby to distinguish his place or situation. By this means they found, that the Sun would not continue to rise and set always at the same distance from the same stars; but, if, for instance, on March the 22d, he would rise and set near those stars, which are placed on the globe, within the constellation called Aries, about a month after they found, that he would rise and set with those in Taurus, which lie in a twelfth part of the whole circle more to the eastward; and, after this manner, the

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the Sun proceeding still forward every day, they found at the end of twelve months it would seem to have gone entirely round that circle, and to rise and set successively with or under all the fixed stars, which are in or near that circular track called the ecliptic.

It was in this manner that the ancients considered the Sun's varied position in the heavens with respect to the earth; for, being ignorant of the true laws of the heavenly bodies, and of the real system of the universe, they, for many ages, did really believe that the Sun moved; but we know that it is the earth that moves, that the Sun occupies the centre of the universe, and never changes place at all; and that all this apparent change of situation is occasioned by the revolution of the earth, on which we dwell, about that luminary. This, however, produces exactly the same appearances as if it was the Sun that moved, and consequently we speak in the usual terms, and talk of the Sun's motion, although that of the earth is always meant.

C H A P. IV.

Of the PRIMARY PLANETS.

I. MERCURY.

MERCURY is a planet, whose diameter is about two thousand seven hundred miles, and is therefore about two thirds of the earth's magnitude. His distance from the Sun is about thirty-two millions of miles, and his mean distance from us about eighty-eight millions of miles, according to Cassini's numbers. He revolves round the Sun in something less than eighty-eight days with the velocity of one hundred thousand miles in an hour; which is almost as fast again as the earth travels; for we do not go above fifty-six thousand miles in that time, and yet that is making pretty good speed too, since it does not want much of a thousand miles in a minute, or fifteen miles in a second: and yet, however amazingly swift this may seem, it is crawling like the American Ignavus, or beast called the sluggard, in comparison of the velocity of the rays of light, which certainly move about

one hundred and eighty thousand miles in the space of a second.

The heat of the Sun in this planet is probably seven times (Mr. Huygens says nine times) as great as with us in the hottest summer; which is, perhaps, enough to make water boil. It is therefore natural to imagine, that his inhabitants cannot be such as we are, since our bodies could by no means bear such a degree of heat.

Mercury is so near the Sun, that he is very rarely seen by any but astronomers, who know how to look after him. He has phases, as they are called, like those of the Moon, and sometimes appears full, and sometimes horned, like her; which, it is easily to be conceived, must be the case of any globe of earth illuminated by moving round the Sun, and changing its position, with regard to him, and to our eyes. It has not been yet discovered, by any spots or marks upon him, that he revolves round his axis, nor consequently what the position of that axis is, though it is probable he performs that motion in a certain and determinate time, as the rest of the primary, and perhaps all the secondary, planets do.

Venus and our earth must needs appear very bright and large to the inhabitants in this planet, and the former will seem six or seven times larger than she does to us, which will help to supply the want of a Moon to him in the night. But there is one more very remarkable phenomenon of him, and that is, that as his orbit is within ours, he must sometimes get between us and the Sun, and then he appears like a little black spot in the face of that luminary, and may very easily be observed and distinguished by a telescope.

II. VENUS.

Venus is the brightest and largest, to appearance, of all the planets, and is distinguished in the heavens by a superiority of lustre from all the others, and incapable of being mistaken for any of them. The distinction to the eye, between fixed stars and planets, is, that the latter have, although a very bright, yet a more placid lustre than the former. The fixed stars are Suns,
and

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and have the source of light in themselves: the planets are globes of earth, or opaque matter, which only receive light from the Sun, and reflect it back again: notwithstanding, therefore, the fixed stars are at an immensely greater distance, it is natural that their brightness should be greater than that of the planets: it is this that gives them that twinkling which distinguishes them from the planets when we look at them; but this is not so absolute a distinction as has been supposed: for the planets which are nearest to the Sun receive their light in so great a degree, that, being also near to the earth, they reflect it with a brightness which does not belong to the others. Venus, in this manner, twinkles a little, and Mercury, although so small, much more. In these, however, the effect is so much less than in the fixed stars, that it cannot confound them with those luminaries. In Saturn, Jupiter, and Mars, it is not seen at all; so that those three planets are entirely, and these two are sufficiently, distinguished from the fixed stars by their light.

Venus does not need this occasion of distinction, for her apparent magnitude, and fine, clear, and lively colour, are sufficient: there needs no other distinction to a star that is the largest in the heavens; but, if there did, this peculiarity of light would give it. Saturn is pale and dead, and Mars is ruddy, and troubled in his light, except just in his oppositions; Jupiter is white and bright, but Venus is still whiter, purer and brighter.

The distance of Venus from the Sun is about sixty millions of miles; and, by some spots which the telescope has discovered in her face, she appears to have a revolution round her axis, the time of which seems to be about twenty-three hours; But neither Cassini at Paris, nor our Mr. Hooke here, though they plainly saw the spots move, were able positively to determine the time of her diurnal rotation round her axis; though the former takes it, as was just observed, to be in about twenty-three hours; and therefore that will be the length of her natural day. Her motion in her orbit round the Sun is performed in a little above two hundred and twenty-four days, and her motion in an hour is about seventy thousand miles.

This

This planet Mr. Huygens takes to have a large atmosphere, which reflects so strong and glaring a light, that her body is rarely seen clear and distinct. She has also phases like the Moon, as was before observed of Mercury: she has no satellites, attendants, moons, or secondary planets, moving round her; because she, as well as Mercury, being so near the Sun, has no occasion to be enlightened by moons, as our earth, Jupiter, and Saturn have. Cassini, indeed, in the years 1672, and 1686, with a telescope of thirty-four feet, fancied he saw a satellite moving round her, whose diameter was about a quarter part of that of Venus; and Dr. Gregory thinks it not improbable, that this might be really a moon to this planet, and takes the reason of its not being usually to be seen, to be, the unsuitness of its surface, to reflect the rays of light: but, as no subsequent observations have confirmed this, it is looked upon to be no more than a conjecture. She is much about forty times as large as our earth, if, as some say, her diameter is seven times as long as that of our planet; and the light and heat of the Sun is about four times as great as it is with us.

As to her being sometimes a morning, and sometimes an evening star, that depends on her position with regard to the Sun and us: when she is in that part of her orbit which is below the Sun, or between him and us, then she is the morning star; but, when she gets into the opposite part of her orbit above the Sun, then she becomes our evening star.

Venus, like her neighbour Mercury, has sometimes appeared like a spot in the Sun, as any one will easily conceive she may, when they reflect that the orbit of the earth includes her's within it; and that therefore she must be sometimes, though very seldom, between our eye and the Sun; and then she will appear like a spot in the Sun's disk.

III. The Earth.

The third planet in the system is the earth, which, by its revolution in an ellipsis round the Sun in three hundred and sixty-five days, five hours, and forty-nine minutes, makes the space of time we call a year.

The

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The earth is near eight thousand miles in diameter, and distant from the Sun eighty-one million of miles. The line which the earth describes in its annual motion is called the ecliptic, and proceeds from west to east, according to the order of the signs of the Zodiac. This motion is the cause of the different seasons of spring, summer, autumn, and winter, and consequently of the several lengths of days and nights in those seasons. In its progress through the ecliptic, it every where keeps its axis in a situation parallel to itself, and equally inclined to the plane of the ecliptic, which is twenty-three degrees and a half, or thereabouts.

The turning of the earth on its own axis, in twenty-four hours, makes it day in those parts which are turned towards the Sun, and night in those parts which are in the shade, or turned from the Sun. It has but one secondary planet, viz. the Moon.

If our fair readers are desirous of being informed particularly of the motion and figure of the earth, of the vicissitudes of night and day, and of the four seasons of the year, they will find them treated of at large in the Introduction to *The Young Lady's Geography*.

IV. MARS.

Mars is the least of all the planets, except Mercury; and the most distant from the Sun except Saturn and Jupiter: his place is next above that of the earth in the system of the universe, his course lying between the orbit of the earth and that of Jupiter; but very distant from both. This planet appears of a dusky reddish hue, and has less lustre than any star in the skies: the diffusion of a reddish colour over this planet is so very singular, that the eye cannot escape observing it, though it deadens the light that would otherwise be sent to the earth from so near a planet.

They compute the diameter of Mars to be about four thousand four hundred miles, and must therefore be much less than our earth, and his distance from the Sun about one hundred and twenty-three millions of miles: he revolves about the Sun in six hundred and eighty seven days nearly, and runs at the rate of forty-five thousand miles in an hour.

By

By some spots, which have appeared in him, the time of his diurnal revolution, is, by Mr. Huygens, settled exactly at twenty-four hours and forty minutes; and the motion of those spots has also discovered, that his axis has very little or no inclination to the plane of his orbit, and therefore the Martial inhabitants can have no sensible difference between summer and winter. Huygens thinks that the colour of the earth in him is blacker than that of Jupiter, or the Moon. His light and heat are twice, and sometimes thrice, as weak as what we receive from the Sun. The telescope has not yet been able to distinguish any moon, or satellites, moving round him; but that will not be a demonstrative reason that there are none at all: for as they are at a great distance from us, so they may be but small, and reflect but a weak and faint light, and therefore may not be visible.

V. JUPITER.

Jupiter is the largest of all the planets, and the scheme, on Plate I. shews that he is much more remote from the Sun, than any of the inferior planets we have been already discoursing of, and therefore heaven has granted him a supply of light by four moons or satellites, which revolve round him as our moon does round us; and these moons, like the satellites of Saturn, are so much less than their primary planets, that they are not visible without long glasses, and therefore were perfectly unknown till the last age.

The diameter of this planet is above eighty thousand miles, and the quantity of matter in him is about two hundred and twenty times greater than that of our earth, and his distance from the Sun about four hundred and twenty-four millions of miles. He revolves round his own axis in nine hours and fifty-six minutes, and about the Sun in eleven years and ten months: and so large is his orbit, that he moves after the rate of about twenty-four thousand miles in an hour.

Jupiter, besides a famous spot, by which his diurnal motion was determined, has appearances in him like swathes or belts, as they call them: these they take to be moveable, and to be formed by the clouds of

of this planet, which seem, like our trade-winds, to lie in tracks parallel to the equator of Jupiter.

He has doubtless something round him like our air; but its texture, gravity, and elasticity, may notwithstanding be vastly different from that of ours. The prevailing opinion, that this planet must be inhabited, is now confirmed by the strongest reason: "For I take it, (says Mr. Harris) that such an apparatus as the making four moons to revolve about, and to enlighten him, (as five such there are also moving round Saturn, besides his ring) I take this, I say, to be a demonstrative proof, that both these planets have some kind of inhabitants, who have eyes to stand in need of light, as well as other senses proper for their natures: for we never find nature doing any thing in vain, but ordering all things with the most consummate wisdom; and we must never believe she would form moons, where there are no people to be lighted by them."

The heat and light of the Sun cannot be above a twenty-seventh part of what we enjoy here, and therefore it must be very dark, dismal, and cold living there, and the weight of all bodies will be double to what they are on our earth.

VI. SATURN.

The most distant planet in our system, is Saturn, being seven hundred and seventy-seven millions of miles from the Sun; and the time of his revolution round him is about thirty years; and yet so very large is his orbit, that he moves at the rate of about eighteen thousand miles an hour. His diameter is about sixty-one thousand miles; and, with regard to the quantity of matter in him, it is about ninety-four times as great as that of our earth; but his density is not much above a seventh part of that of the matter of our planet. As to light and heat, it is probable, that he hath not above a ninetieth part of what we enjoy by the Sun. Indeed, in order to supply this great defect of the Sun's light, occasioned by so great a distance, our all-wise creator hath furnished him with five moons, or attendants; the largest of which, the only one that

is commonly seen, is the fourth in order from his body; and he bears the name of the Huygenian satellite, because first discovered by Mr. Huygens.

It doth not yet appear, that Saturn hath any diurnal revolution round his own axis.

The most surprising and unparalleled phenomenon of all in this planet, is that which we call his ring: it is a vast body of earth, as is most probable, of perhaps seven or eight hundred miles in thickness, which, at the distance of about twenty-one thousand miles from Saturn's body, and with just as great a breadth, is placed in a circular arch, round about the planet, in figure much like the great wooden crane-wheels, in which men or horses walk to raise goods or draw water. It is placed exactly over the equator of Saturn, and is not any way contiguous to his body, nor supported by any thing. The surface of this ring is not rough, and full of hills and protuberances, as that of the Moon in most places is, but even and plain, as it is in those regions of the Moon, which some, because of their great evenness, have judged to be seas.

The thickness of the ring comes not into astronomical observation, appearing but as a line; and, though the two broad surfaces of the ring reflect a good deal of strong light, yet the marginal surface of it, or its edge or middle part, between the two eminent surfaces, reflects hardly any at all. The plane of the ring is inclined to that of the ecliptic, with an angle of about thirty-one degrees; and this inclination, in the course of one entire revolution of Saturn round the Sun, hath some variation. This occasions the planet sometimes to appear without any ring at all, as when the Sun happens to be in the plane of the ring; and, at other times, with *an/a*, as they call them, or handles only, when but little of the surface of the ring can be seen. At all other times the ring will appear in an oval form, which sometimes will be more, sometimes less oblong.

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CHAP. V.

Of the SECONDARY PLANETS.

The MOON.

THE Moon's diameter is reckoned to be almost two thousand two hundred miles: her magnitude, or rather her mass, or the quantity of matter in her, with regard to the earth, is about one fortieth part; but then the density of her to that of the earth is as nine to five: so that, if she has any inhabitants, as it is highly reasonable to suppose all the planets have, they cannot be of such constitutions as we are; and, though some of our astronomers have lately concluded, from some observations made in eclipses of the Sun, that she hath an atmosphere, or air about her, like our earth, yet it is probably of a very different nature from ours, without any clouds, rain, hail, or snow; because, whenever our air is clear, we can always discern the Moon's face, with, as well as without, a telescope, to be bright, clear, and distinct, which, it is presumed, could not well be, if her atmosphere were like ours.

Though the Moon appears to the common observer larger than any of the heavenly bodies, it is the least of them all. Things appear greater or less, in proportion to their distance from the person who views them; and the Moon is nearer, by multitudes of degrees, than any other of the heavenly bodies. We are indeed to look on this luminary in a light quite different from that in which we see all the others. The distance of the Sun is immense; the planets roll round that Sun, as the earth also does, and are likewise very distant from it; the fixed stars are yet vastly more remote than all these, so far indeed, that their distance goes beyond computation, and we can make no conjecture about it: on the contrary, we are to regard the Moon, as not placed among these, nor revolving, like the others, round the Sun; for it revolves round our earth alone, and that at a little distance.

When

When we speak of distances, under the term *little*, in regard to heavenly bodies, we mean comparatively with that of the others; for the least absolute distance, when put down singly, will appear great, and the smallest magnitude immense. The Moon, which is but a speck, in comparison of the other heavenly bodies, and in comparison of their places, is so near to us, yet is, in her mean distance from us, two hundred and forty thousand miles, and its diameter is nearly a fourth part of that of the earth's; it is about two thousand one hundred and seventy-five miles: the surface therefore contains no less than about fourteen millions of square miles. This, considered in itself, is a considerable large object; but, when considered as a heavenly body, and in comparison with the others, it is little.

As the Moon is the nearest to the earth of all the planets, her motion also is the quickest, the complete revolution being performed in about the compass of a month.

Let us now proceed to say something of the mountains in the Moon. Astronomers have given the names of mountains to those parts of the Moon's surface which are considerably elevated above the general level. These are very numerous, and the observation of them is one of the most pleasing that the telescope affords.

A very powerful telescope is not necessary for this purpose. Indeed, the view is much more pleasing, when a larger part of the Moon's disk is taken in at a time, than can be by those instruments which magnify a great deal. Another circumstance is also proper to be observed, in order to set those right, who are not much accustomed to these things, as to seeing them to advantage. It is a common error to chuse a full Moon for the time of the examination; but this is, of all times, the worst that can be chosen; for the way we distinguish the elevations, or mountains, if they may be so called, in the Moon, is by the shadows which they project from them; but these shadows are imperceivable at the time of the full Moon, the light of the Sun at that time falling full upon the surface; whereas it must come obliquely, in order to the causing

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of those shadows : nor is this all the disadvantage ; for we are not only deprived of the sight of those mountains which there really are on the surface of the Moon at this time, but we take those things for mountains which are not so. Those spots on the Moon's disk, which are called after the name of Tycho, Copernicus, and Kepler, have a brightness which makes them seem elevated above the surface at this time, and it is natural to take them for mountains, while we overlook those parts that really are elevated. These spots are only harder, or smoother parts of the globe of the Moon than the rest ; for, when the Moon gets into her decrease, and the mountains are discovered by their shadows, these spots cast no shadow at all, but, by degrees, grow more and more faint. The full Moon is a pleasing sight through the telescope ; but it is not the face on which to discover these mountains.

Astronomers talk also of water in the Moon ; but what they mean by it cannot be water : it is probable there is no such fluid in the Moon : the dark places they express by this name are, more probably, immense tracts of forest, or some other thing absorbing the light, not reflecting it, as water.

We are told also of mountains in Venus, like to those in the Moon ; and it is certain that there are such, but they require glasses of a more powerful kind to view them, and an accustomed eye, as well as a favourable season. They may be distinguished very clearly here in England by those who take the proper opportunity ; but the greatest discoveries concerning them have been made in Italy, where the air is clear, and much more favourable for such observations.

It may not be improper, before we conclude, to describe the phenomena of the different appearances of the Moon, as viewed from the earth, and considered as a spherical body illuminated by the Sun.

The Moon, being a secondary planet, accompanies the earth, T, (Plate II.) during its revolution about the Sun, in its orbit, R R, and moves in its own orbit the same way as the earth does, from A through B, C, &c.

The

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The Moon, like the primary planets, being in orbit, though spherical body, reflecting the Sun, & being turned upon it, it is evident, that half of her being turned towards the Sun, is illuminated and bright, while the other half, that is turned from the Sun, continues obscure and dark. Only that hemisphere of the Moon, which is towards the earth, can be seen by an inhabitant of the earth viewing her; consequently the phases of the Moon will be various, according to the various positions of the illuminated hemisphere, which is turned towards the earth.

If the Moon be at A, as in the diagram, the point just opposite to the Sun, which we will suppose to be S, and the earth T, it is evident, that the whole enlightened face of the Moon is turned towards the earth: this phase, or appearance of the Moon, is called the Full Moon. If the Moon be removed to B, part of the bright or illuminated face will be turned from the earth, and part of the obscure or darkened half turned towards it: her appearance to the Moon will not appear full, but gibbous, or a little obscure or obscure in her light. The Moon arriving to the position C, where the angle CTS is a right angle, the Moon is one of its distances, half the hemisphere, which is turned to the earth, is illuminated, and half dark; on which account it will appear a half-moon, and in the distance of 90 degrees.

If the Moon having got further, for instance, to D, but a little of its face that is turned to the earth is enlightened, much the greater part remaining dark; and, consequently, the enlightened part will appear narrowed, by reason of the Moon's really spherical, but apparently plain figure.

At length, when the Moon is come to the point E, or in conjunction with the Sun, all the enlightened half is turned from the earth, and consequently the Moon will be entirely dark, and become a new moon. Because it will soon appear at F. Afterwards, being upon the concave, it will appear a half-moon at G, at the end of the first quarter, as it did at C, at the beginning of the last quarter; then gibbous at H, till it becomes full again at A.

The Moon, like the primary planets, being an opaque, rough, spherical body, reflecting the Sun's rays falling upon it, it is evident, that half of it, being turned towards the Sun, is illuminated and bright, while the other half, that is turned from the Sun, continues obscure and dark. Only that hemisphere of the Moon, which is towards the earth, can be seen by an inhabitant of the earth viewing it: consequently the phases of the Moon will be various, according to the various habitude of the enlightened hemisphere, which is turned towards the earth.

If the Moon be at A, as in the scheme, the point just opposite to the Sun, which we will suppose to be S, and the earth T, it is evident, that the whole enlightened face of the Moon is turned towards the earth: this phase, or appearance of the Moon, is called the Full Moon. If the Moon be removed to B, part of the bright or illuminated half will be turned from the earth, and part of the obscure or darkened half turned towards it: hereupon the Moon will not appear full; but gibbous, or a little deficient or obscure in its light. The moon arriving to the situation C, where the angle CTS is right, and the Moon in one of its quadratures, half the hemisphere, which is turned to the earth, is illuminated, and half dark; on which account it will appear a half-moon, and in the decrease.

The Moon having got further, for instance, to D, but a little of its face that is turned to the earth is enlightened, much the greater part remaining dark; and, consequently, the enlightened part will appear horned, by reason of the Moon's really spherical, but apparently plain figure.

At length, when the Moon is come to the point K, or into conjunction with the Sun, all the enlightened half is turned from the earth, and consequently the Moon will be entirely dark, and become a new-moon; because it will soon appear at F. Afterwards, being upon the increase, it will appear a half-moon at G, at the end of the first quarter, as it did at C, at the beginning of the last quarter; then gibbous at H; till it becomes full again at A.

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For greater evidence and clearness of the whole, we have drawn the appearance of the Moon as seen by us, corresponding to every distinct situation, and placed it just behind it.

Though the time of the Moon's revolution about the earth be but twenty-seven days, seven hours and three quarters, which is called a periodic month, yet by a month, or entire lunation, is commonly understood all that space of time that is spent from one new Moon till the next following, which is greater than the above-mentioned periodic month; because, during the periodic month, in which the Moon, departing from the point K, where the new moon now happens, returns to it again; the earth itself, together with the Moon, its attendant, is removed an entire sign: so that the said point of the orbit of the Moon, K, is more towards the west of the Sun, and consequently the Moon is not yet arrived to a conjunction with the Sun, but still wants two days and five hours to it, or to become new; that is, to finish an entire lunation, and all the several changes of its appearances; which space of time is called a Synodic month, and consists of twenty-nine days, twelve hours and three quarters.

A little before and after a new Moon, viz. when the Moon is in D or F, the rays of the Sun, reflected from the earth, meeting with the Moon, are the cause of that faint light, by which the rest of the Moon's disk, besides its horns, is then rendered visible; but, when the Moon is got out of the way of the reflexion of the earth's light, that faint light vanishes, being falsely supposed native.

The Satellites of JUPITER.

The satellites of Jupiter are four, and may be seen, with an ordinary telescope, in a clear night. The innermost moves round him in one day and eighteen hours, the second in three days and thirteen hours, the third in seven days and almost four hours, and the outermost in fifteen days and sixteen hours and an half. The nearest is about one hundred and thirty thousand miles from that planet, the second about three hundred

hundred and sixty-four thousand, the third five hundred and eighty thousand, and the fourth or outermost is about a million of miles distant from him.

The Satellites of SATURN.

The secondary planets, or moons, about Saturn, are five, which are not visible but with very good telescopes. The innermost of these moons revolves round Saturn in one day, twenty-one hours, and twenty minutes; and is distant from him about one hundred and forty-six thousand miles, and performs his revolution in two days, seventeen hours, and forty minutes. The third takes up in its revolution four days, thirteen hours, and forty-five minutes; and is distant from the centre of Saturn about two hundred and sixty-three thousand miles. The Huygenian satellite is about six hundred thousand miles from him, and moves round him in fifteen days, twenty-two hours, and forty-minutes. The last is one million eight hundred thousand miles distant from Saturn, and takes up seventy-nine days, and twenty-two hours, in revolving round him.

It is highly probable, that there may be more satellites than these five moving round this remote planet; but their distance is so great, and their light may be so obscure, as that they have hitherto escaped our eyes, and perhaps may continue to do so for ever, since it is not likely that our telescopes will be much further improved.

CHAP. VI.

Of COMETS.

IT is generally agreed among astronomers, that comets are a kind of planet or bodies revolving about the Sun in elliptical orbits, whose periodical times and motions are as constant, certain and regular, as those of the planets; and that their bodies are solid, compact, and durable, like the planets, but abundantly denser, as they pass through the greatest extremes of heat and cold without any apparent dimi-

nation or alteration, which their orbits and periodical times plainly discover.

All comets appear to be spheres, with large atmospheres surrounding them, some fifteen or sixteen times more in diameter than their bodies are, so consequently three or four thousand times as large; which, in their perihelions, or nearest access to the Sun, by the intense heat emitted therefrom, are so much rarefied, as to be abundantly lighter than the Sun's atmosphere, and extended into long lucid tails towards those parts opposite the Sun, and are then properly called tails.

As comets recede from the Sun, their tails diminish, and atmospheres encrease gradually, until they approach their aphelions, or greatest distances from the Sun; then their tails are contracted into circumambient atmospheres again.

The same comet, in one and the same position between the Sun and any fixed star, will always have the same aspect.

The bodies of comets, especially those which have the shortest periodical times, are of themselves but little larger than the Moon, which their perihelions demonstrate: so that it is their atmospheres and tails which make them appear conspicuous.

Comets, like the planets, move in elliptical orbits about the Sun, with this difference, all the planets move from east to west, in the plane of the ecliptic, and in orbits nearly circular, whilst the comets, in their very elliptical orbits, traverse the compass in all directions (the plane of the ecliptic only excepted) and that in so wonderful a manner, as not to interfere in one or the others orbits.

Although comets never move in the plane of the ecliptic, yet their orbits incline thereto, more or less: the inclination of that which appeared in 1682, is about eighteen degrees; so that it cannot approach nearer to any of the planets than about one third of that planet's distance from the Sun, and the nearest it can approach the earth is at seventy-five times the Moon's distance therefrom: Hence it is evident, that

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no hurt can happen either to the Earth or Moon from its tail, during its short stay in the planetary regions.

The smaller comets, like the inferior planets, have smaller orbits, perform their revolutions in smaller periodical times, and in their perihelions are much nearer to the Sun than the larger can be, which have larger orbits, and take longer periods in performing their revolutions.

Hence it appears very probable, that both planets and comets are governed by the same stated laws: if so, it is by no means unlikely, that comets have diurnal motions round their axis, as well as annual periods round their orbits.

Astronomers allow, that there are many comets which traverse the solar system, and of which they constitute by far the greater part; as those which have been taken notice of since Julius Cæsar's time are about forty, which differ either in their appearances, periods, or trajectories, so consequently are different comets; besides those which made their appearances from the creation to Cæsar's time, and have not since been accounted for: and how many those are which have their trajectories beyond the south-east, and south-west limits of the European horizon, where no observations can be made, as well as those which pass by us in the day-time, and that in the five summer months, in which not one half the number have appeared to us as have in the other seven months, is difficult to say. All these things considered, we must, however, conclude, that their numbers are very great, when compared with the planets, which, together with their secondaries, are but sixteen. Notwithstanding which, there are no more than three whose periodical times are yet known, the largest of which takes no less than five hundred and seventy-five years to complete one revolution. This appeared in 1680.

The ancients looked on the appearance of comets to be no other than large meteors exhaled from the earth, and elevated by their own levity into the upper regions of the air, there set on fire, and continued blazing till they consumed away for want of fuel; and Aristotle himself seemed to be of this opinion.

The cunning augurs, or diviners, could not let such phenomena pass by without assigning their uses, which they did to the purpose, by affirming them to be nothing less than the heralds of the gods, and their appearances to be the forerunners of wars, famine, destructive plagues, deaths of great personages, and ominous in the highest degree; which opinion still prevails, where bigotry and enthusiasm reign. Nay, some there are, who go so far as to imagine, every comet to be a hell, or place of torment, appointed for the damned; and this opinion carries no small weight with it, as these gentlemen have very luckily hit upon a hot and a cold place of torment alternately in one and the same place; the one as terrible to the inhabitants of the frigid zone, as the other can be to those who inhabit the temperate and torrid zones, which evidently proves that this hypothesis has its uses.

There are others, who have taken no small pains to prove, that comets are appointed to supply the Sun with fuel, by continually approaching nearer to its body every revolution they make, as at length to become totally swallowed up therein; but this notion is quite as absurd as any of the former, as neither their constituent parts nor magnitudes can answer the purpose: besides, it is a query whether the elastic force of a comet's tail doth not balance the Sun's attractive force, so far as to prevent such a conjunction. And those of the first rank, reasonably suppose, that by the rarefaction and expansion of their tails, the vapours contained therein, which are the most fluid parts extremely rarefied, are attracted by the gravitation of the planets, and, mixed with their atmospheres, become a supply of that continual decrease of fluids in the planets, caused by the consumption of vegetation and putrefaction: for common experience shews, that air itself, when over-heated or closely confined for some time, loses its elasticity and purifies; but a supply of fresh air shall cause the putrefied air to recover its elastic force again.

Doctor Cheyne proceeds further, and thinks that the fine rarefied fluids, thus attracted from the
tails

tails of comets throughout the planetary regions, supply the Sun and planets with light, heat, gravitation, and every thing useful and necessary to preserve life and vegetation; and quotes Sir Isaac Newton's authority for the same, who admits of a very thin and active fluid, which readily pervades the pores of all bodies whatever, and, by its elastic force, expands itself quite through the universe; but is much rarer within the pores of dense bodies, as those of the Sun, the planets, and the comets, than it is at distances from them; and it grows more dense as those distances increase.

It is to this fluid, which he calls æther, he attributes the cause of gravitation in the heavenly bodies, the reflexion and the refraction of the rays of light, the duration of heat in hot bodies, the communication of heat to cold bodies, and animal motion, thereby making it the first created substance by which every individual part of the creation acts and subsists; which he hath so far confirmed by experiments upon pendulums, and of communicated motion and heat through an apparent vacuum, sufficiently to prove that there is such a fluid as he calls æther; but what it is, he expressly declares he cannot tell.

The late great naturalist, Mr. Boyle, in his account of the origin of air, remarks, that there is still a more subtile fluid than that of air, consisting of those exceedingly minute atoms of magnetical effluvia, besides other innumerable particles emitted from the bodies of the celestial luminaries, of an elastic substance, the denser parts of which he supposeth to be attracted into the several atmospheres of the heavenly bodies, whilst the more subtile parts occupy the intermediate space between one fixed star and another, as well as between the planets of our solar system.

Another argument in favour of æthereal matter is, that the weight of air, and its elastic force, are always equal to each other, and produce an equilibrium in every part of the atmosphere, whereby the rarer particles of air in the upper regions of every planet's atmosphere may be, and probably are, so far expanded, that the atmospheres of every body, in all the systems

of the universe, meet each other, and, mixing together, constitute that fine ætherial medium which fills the vast abyss of space.

Others there are, who make it a question, whether there be any such thing in nature as ætherial matter; as scarcely any two agree alike in favour of it: and how is it possible they should, since none of them pretend to know what it is? yet Sir Isaac Newton's account of its properties so well agrees with the first day's work of creation, as to lay the question absolutely aside; therefore him alone we shall follow.

He further observes, that the elastic force of this medium is so exceeding great, as to impel all bodies from the denser parts thereof towards the rarer, with all that power which we call gravity: and that gravity is greater on the surface of the smaller planets than it is on the large ones, in proportion to their bulk, which, in return, are of themselves abundantly hotter than the smaller ones can be, which have not the quantity of matter and motion to attain and conserve that heat; and the more all bodies are heated, the more they are dilated and rarefied; and a continual rarefaction of the bodies must cause the same in their fluids, which, through a course of time, must so far divest them of elasticity, as to cause gravity in the bodies in a manner to cease. But common experience informs us, that the force of gravitation in all bodies is the same now as it was in former ages; that each of the heavenly bodies now observes the same stated periodical times, diurnal motions, inclination of its axis, and the equinoctial points still keep the same recession, as were known to the ancients for more than two thousand years past; which evidently proves that there hath always been a continual and regular supply of ætherial fluids constantly pervading the bodies, and mixing with the atmospheres of the Sun and planets, so as to preserve elasticity and gravitation in one and the same fixed state: and as this elastic fluid is abundantly denser in the vastly remote ætherial regions (where the Sun appears scarcely larger than the planets Jupiter and Venus do to us) than it is in the planetary regions, where the Sun's rays are continually diffused

diffused in such quantities as to be much denser than this medium; and as these opposite bodies continually impel each other, so cannot of themselves unite; it is plain that there must be particular ways and means for conveying this fluid, not only quite through the planetary system, but into the atmospheres and bodies of the planets themselves; and what ways and means can we imagine so apt as by the comets only?

Are not the great density of their bodies, their vast atmospheres, their extensive almost right-lined orbits, in which they search the hidden recesses of nature, paths quite unfrequented but by them only, and their traversing the solar system in all directions, almost a demonstration that they were on purpose designed for that end?

Further, by way of illustration, let us conceive that we now see the comets, one and all, really as they now are, traversing the solar system in all directions; some regularly receding from the Sun in their almost right-lined orbits, with the most surprising rapidity, directly towards the aetherial regions, and, before which they have well attained, see them gradually slacken their paces quite home to the utmost limits of their boundaries, whilst their huge rolling atmospheres are attracting, by cohesion, large quantities of aetherial fluids of various qualities, and, mixing together, they become fitly proportioned for the uses assigned them; and then, as it were in a moment, to see them change their course towards the Sun, and, as they advance, still continue amassing to themselves the choicest treasure of nature's storehouse, till, through a course of some centuries, the shortest some scores of years, they again approach the planetary regions; and then to see their circumambient atmospheres begin to change themselves into long cylindrical tails, which encrease with their velocities, so as to become eight or ten thousand miles in diameter, and perhaps an hundred times that in length, by which the fluids therein contained are so exceedingly rarefied, for the smallest star visible to the naked eye to be seen through them! then what can remain after such a preparation for gravitation, but their being easily attracted into the atmospheres of the Sun and planets, and there mixing with them, to preserve the elasticity of their fluids.

fluids, whilst the rarer particles are penetrating the internal parts of their bodies, so as to conserve gravitation in every individual throughout the planetary system?

As one of these comets performs its periodical course in about three fourths of a century, another in about thirty years more than a century, whilst others make longer periods, and, as it hath been supposed, one and all for the same office, doth it not appear self-evident, that elasticity and gravitation must both quickly subside, were it not for the comets: so that it may be said of them, the planets, and the Sun, as what we know of the body and its members, that it is by the one and the other that all subsist.

CHAP. VII.

Of the FIXED STARS, &c.

WHEN we cast our eyes in the night up to the concave of the skies, we see a number of stars, different in magnitude and in lustre. It is easy to separate the planets from the fixed stars, by their steady light, none of them, except Mercury and Venus, having any thing of that vivid lustre, or twinkling to the eye, which we see in the fixed stars; and even they, but very little of it.

The fixed stars being thus distinguished from all the other heavenly bodies, it remains to regard them as varying from one another: this is only in apparent magnitude, and in the degree of that brightness which is peculiar to them as fixed stars. Those of the fixed stars which appear largest appear also brightest, and the smallest faintest: this would refer the difference in apparent magnitude to distance only; but there are some exceptions. We know that distance diminishes light as well as bigness; but there are the *Syrus*, *Aldebaran*, and some other stars, which shine with a lustre greatly superior to the others, that are of equal apparent diameters; therefore there is some difference in the brightness of their fire.

It

It was but by slow degrees that men became acquainted with the knowledge of the stars, and that vast space, which they occupy, the heavens. But they no sooner saw, than they began to enquire into the causes of what were seen there. Plato and Aristotle supposed the heavens solid, although transparent, and supposed the blue space extended over our heads firm as a sapphire. They placed the earth in the centre of the universe, and supposed it to be wholly at rest, while they divided that space into several distinct heavens, but all of the same firmness and solidity.

Ptolemy discountenanced this system: he said, that the deities (the name by which he called the stars, for they were adored in his time) moved in an ethereal fluid. Notwithstanding the many errors in the system he has given us, (for the sole principle of his placing the earth in the centre must make way for a thousand) we cannot but admire the address, by which, though ignorant of the truth, he, in some way, explained the apparent motion of the heavenly bodies, and framed a system, which brought them into the reach of calculation.

The succeeding astronomers agreed in his doctrine of the nature of the heavens, and we are at this time sensible, that the space which is called by that name is supplied only with æther, or with a fluid more fine and subtile than air itself. Most of the succeeding writers on the subject agreed with him also, that the planets rolled about the Sun; but it was not till about two hundred years ago, that Copernicus revived the system of the old Pythagoras, and asserted, that the Sun was placed in the centre of the universe, and that the earth, as well as all the other planets, performed a revolution round it. What Copernicus thus established, all the succeeding philosophers and astronomers countenanced till the days of Sir Isaac Newton, who, from the observations he made, and the laws he delivered concerning the whole system of the universe, proved and supported it in such a manner, that it will never be overthrown. Men believed before, that it was truth, but they are now assured of it; what was
but

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but probable conjecture, is now a perfect certainty, and there can be no more doubts about it so long as the world itself holds together.

The heavens, to follow the path of this true system, are of an indefinite extent; they are filled with a fluid much finer and thinner than our air, and extend beyond all limits, of which we have any conceptions. There being nothing visible to us in the remote parts of the heavens, we can only consider them as the places of the stars: all the fixed stars are situated in them; and, though they seem so near to one another in our view of them, they are doubtless at an immense distance each from the other, and at a very different distance with respect to us. We must have a vast idea of this space, when we consider that the largest of the fixed stars, which are probably the nearest to us, are at a distance too great for the expression of all that we can conceive from figures, and for all means of admeasurement: the smaller are, doubtless, more and more remote, to the least, or those which are of the sixth magnitude. These must be in a part of the heavens vastly more remote from us than the others; and yet, beyond these, telescopes discover to us more stars, too distant to be at all perceptible to the naked eye, and as these instruments are more powerful, they discover yet more numerous ones. We may conceive by this, in some measure, what, and how great, must be that extent, which admits of no known limits. Plato and Aristotle suppose the heavens terminated somewhere; *but what must it be that is beyond them?*

In that little space of the heavens, which makes the system, of which our world is a part, the Sun occupies the centre. The Sun is, in reality, nothing more than a fixed star, though, from our being so near to it, it appears vastly larger. Round about this Sun, as was before observed, rolls our earth, and with it the other five planets: of these, the two nearest perform their revolutions alone or unattended; but three of the other four, calling the earth one, and thus raising the number to six, have lesser planets rolling round them: the earth has the Moon, her satellite;

Jupiter

Jupiter has four, and Saturn has five. It is singular that Mars, which is placed at a greater distance from the Sun than we are, should have no satellite, but it is supposed he has none, the best astronomers hitherto not having been able to prove the contrary. The globe of Jupiter is, in its solid contents, nine hundred times as large as our earth, and his satellites, which are too distant to be seen by the naked eye, are each of them fully of the bigness of this earth; the fifth of those of Saturn is much larger. We are not to be prejudiced from our near sight of things, or to be amazed, that such a vast globe as our earth should roll round the Sun, accompanied by the Moon: we find vastly larger, and more distant globes, performing the same course, whose very attendants are equal to this earth, or more than equal to it, in bigness.

The distance of Saturn (the remotest planet in the Solar System) from this earth is very great; but vastly beyond that, a space of unlimited extent, filled with æther, is occupied by millions of fixed stars, or globes of fire, that shine with their own proper lustre, whereas the brightness of all the planets is only that light which they receive from the Sun. The immense expanse, in which they are placed, is called the heaven of the fixed stars; and they are called fixed, because they remain always at the same distance from one another. These the ancient astronomers have divided into constellations, under the names of various persons and of various animals, under the outlines of which they have collected certain stars, in order to the speaking regularly of them, with regard to their places in the heavens.

The distance of the fixed stars is, as was before observed, too immense for ordinary calculation: some idea, however, may be formed from what the greatest men have thought of it, by whom it is supposed, that if a bullet was to be discharged from one of them, the very nearest, and should fly to the Sun with that rapidity with which it leaves the mouth of the cannon, it would be twenty thousand years in reaching that luminary. The most remote that we see, even by
telescopes,

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telescopes, are not to be understood as the most remote in the heavens: that instrument has its limits like our eyes, though it reaches farther; but the extent of the heavens and the creation seems to have no limits. The heavens, therefore, appear indefinite in space, and the stars unnumbered and immoveable. These, as they are truly so many suns, may be supposed all to have planets revolving round them; and thus the space is filled in a manner worthy the ideas we have of the Creator. Huygens had given the planets the name of *celestial earths*; and it is probable, that they are, in many respects, like to this globe which we inhabit; and that, as the plants and animals which abound with us are formed out of the principles of this earth, so there are on those globes plants also, and animals formed out of the constituent particles of those, and therefore calculated for living on them. We can easily conceive, that creatures like ourselves, like the animals which inhabit this earth, or the plants which grow upon it, could not live in the extreme cold of Saturn, or in the extreme heat of Mercury; all must be solid ice in the former, and upon the surface of the latter the heat is so great that it will make water boil. Though creatures of our texture could not live in such worlds, He, who created us and our world, and appropriated the one unto the other, could also form creatures proper for the other worlds: he has created

us, and we see, that he has fashioned them in many respects like to this earth, their form, their motion, and their several laws, of the same kind: he could, therefore, as easily create inhabitants for them; and, as he has been so bountiful to this small portion of the universe, the earth, it is not to be supposed that he has neglected such vast orbs. It is most probable, that the fixed stars, being, as they assuredly are, so many suns, every one of them has a number of planets revolving round it, for this is their use; and that thus the whole heavens are filled with worlds, and those worlds with inhabitants: an extent like this is much more agreeable to the majesty of the Divine Creator, than the supposing

this little spot, among the millions that surround us, to be the only part of the creation inhabited, and that the rest were made for us to look upon. This assuredly is not the case, since many of the fixed stars are beyond our sight; and even, if all were within the reach of it, it is unworthy of our reason, and inadequate to the ideas we, in other respects, establish in our minds of the Creator, that he should have made them for our pleasure. We see that the Sun and stars alone are bodies of fire: the planets, we discover, to be earth-like this, fit for inhabitants, and have the same vicissitudes of night and day, and of the seasons, though at different intervals. The sole office of the Sun is to give this light, and be the centre of their motion; for in itself it is not to be conceived that it can be of any use at all. If this be the case, why should we suppose so many suns, as we see in the heavens under the form of fixed stars, created to be useless, or to spend their light, many of them with respect to us, wholly in vain, because we can see nothing of them?

CHAP. VIII.

Of the Division of Time.

THE most considerable parts of time are, a day, an hour, a week, a month, and a year. The first of them is a day, because it is a space of time most obvious and known by us, and is either natural or artificial. A natural day is the duration of an entire apparent revolution of the Sun about the earth. The artificial is that part of the natural day, during which the Sun is above the horizon, and is opposed to the night, which is taken for the Sun's continuance below the same; but the natural day takes in both.

Most astronomers begin the day at noon; but Copernicus, following Hipparchus, begins it at night. Different nations make different beginnings of the day; the Babylonians began their day with the rising of the Sun; the Jews and Athenians with the setting of the Sun, as the Italians do still; the Egyptians at midnight, which is the custom of the English, French, Germans,

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Germans, and almost all other European nations; for we naturally refer the night, which we spend in sleep and silence, partly to the preceding, and partly to the following day. The Umbri^a anciently made the noon to be the beginning of their day, which is observed by the Arabians at this time.

Though the artificial day was hardly divided anciently any other way than into the morning and the evening, and the night into watches, yet, afterwards, the natural day was more accurately divided into twenty-four parts, called hours. Hours are either equal or unequal: an equal hour is the twenty-fourth part of a natural day. This sort of hour was always used by astronomers, and is now in use almost among all nations. The Italians reckon the hours from one to twenty-four, from the beginning of the night, that being the beginning of the natural day, and their clocks are made after that manner; but we, the French, &c. reckon not twenty-four, but twice twelve hours, perhaps, that the number of the strokes struck by the clock might not be too tedious: so that we divide the day into the hours before noon, and the hours after noon.

An hour is commonly divided into four quarters, which are called points by some, a more minute division being in most businesses unnecessary; but the astronomers, and now all the politer sort of people, subdivide it into sixty minutes, and each minute into sixty seconds. An unequal hour is the twelfth part of an artificial day, as also the twelfth part of the night. It is called temporary, because of a various length in different times or seasons of the year: thus the summer diurnal hour is longer than the winter, and the nocturnal shorter; and the diurnal hour in winter is shorter than the nocturnal. At the time of either equinox, the diurnal hours are equal to the nocturnal, and then these unequal hours become the same with the equal ones described above, upon which account these equal hours are called by authors equinoctial hours. The Jews, Grecians, and Romans, made use of these temporary hours. Such as begin the civil day at the morning or evening, do it because the

the Sun is then in the horizon, the most sensible of all the circles of the sphere.

A week is the most ancient collection of days, as is evident from the sacred writings. The Jews used this collection of old; and, since the reception of Christianity, other nations too. Every day of it has a name given to it from some of the planets.

Let us now proceed to explain the division of time into months and years, and the various sorts and collections of them.

Though a month be properly that space of time wherein the Moon goes through the zodiac; yet, since there are about twelve months that pass while the Sun runs once through the ecliptic, that space of time also wherein the Sun runs through one sign of the zodiac, is called a solar month, which is about thirty days and an half. Again, the lunar month is either periodic, in which the Moon, having departed from any point of the zodiac, returns to it again, and is something less than twenty-seven days; or synodic, which is something more than twenty-nine days and an half, wherein the Moon runs through all its several phases, and on that account is of principal use in the marking of time. Both the solar and synodic lunar month, is either astronomical or civil, according to the different custom and institution of each nation: for some, as the Egyptians, liked the solar months, and made each of them to consist of thirty days; and, to complete the year, at the end of twelve such months, they annexed five days, made up of those twelve times ten hours, by which each solar month exceeds thirty days. The generality of the ancients fancied the synodic lunar month to be longest, such as the Jews anciently, the Grecians and Romans to Julius Cæsar's time, and the Mahometans at this day: but that this sort of lunar months, which do not consist of whole days, might be fitted to civil use, where pieces of days cannot be taken notice of and considered, they made their civil months alternately of thirty and twenty-nine days, calling the former *full*, and the latter *cave* months: so that two such months are equal to two lunar months of twenty-nine days and a half each; and the new

moon

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moon would not sensibly remove from the first day of the civil month in the course of some years.

A year is sometimes taken for the time of the revolution of a planet through the zodiac, in which sense a month is sometimes called a year; and sometimes for the time of an entire apparent revolution of the fixed stars through the zodiac, which they call the *Annum magnum*, or great year: but a year is properly that time which the Sun takes in running through the zodiac, and is of two sorts, the astronomic and the civil. The astronomic is also twofold, according to the two different bounds of the Sun's revolution, namely, the syderial and tropical. The syderial year is the space of time, in which the Sun, having departed from a fixed star, returns to the same, and is three hundred and sixty-five days, six hours, and ten minutes nearly. The tropical year is that, wherein the Sun, departing from one of the cardinal points, the equinoxial or solstitial, returns to it again, and is something less than the syderial; because the cardinal points of the ecliptic themselves go backward, and, as it were, meeting the Sun, make the Sun to return to the same point of the ecliptic something sooner than to the same fixed star, where that point of the ecliptic was, when the Sun was before in the said point. This tropical year is three hundred and sixty-five days, five hours, forty-nine minutes, and twelve seconds, very near, and wants about twenty-one minutes of the syderial year.

The civil year is the space of time, that the motion of the Sun or Moon, or both, points at, received by the settled custom of any nation. Hence it is evident, that there are three terms of the civil year, namely, either purely lunar, purely solar, or luni-solar, which is made up of both. The lunar year consists of twelve lunations, or synodic months, that are finished in three hundred and fifty-four days, at the end of which the year begins again; and, since this year wants near eleven days of the tropical year, it comes to pass, that the beginning of this year, falling upon the spring now, in eight years time would fall upon winter, and after as many more upon autumn, then upon summer, and

and lastly, at the end of thirty-three years, return to the spring again. This is called the wandering lunar year, because its beginning wanders through all the seasons of the year, and that in the memory of one man: it is also called *Annus solutus*, because free and disengaged from the motion of the Sun, which is not at all considered in the ordering of it. This sort of year is in use among the Turks, and seems to be found out at first in those countries, where the differences of summer and winter are not very evident and sensible; and where, for want of astronomy, the return of the Sun to the cardinal points of the zodiac, which define the solar year, is not easily known: on which account, taking the signs of the seasons from the Moon, they took the beginnings of their year from the beginnings of her phases or appearances; and there is no number of lunations, that comes so near to the solar year, (which they had some knowledge of) as the twelve. It is probable, the reason of their beginning the civil day from the sun-set, is to be taken from the Moon; because it seems necessary for them to begin the civil day with their year and month, that is, with the new-moon, which, at first they knew no otherwise than by the help of the naked eye, which was, when they saw the new-moon in the evening immediately after sun-set. Upon this account, the first, second, third, &c. day of the month, was called the first, second, third, &c. Moon, and the day of the full-moon was consequently called the fourteenth moon.

Such of the ancients as were willing to retain the lunar year, thought it notwithstanding proper to adapt it so to the Sun, that its beginning might be in a manner fixed, and that it might keep the cardinal points of the year shewn by the seasons, from receding much from their months; and to this purpose they used intercalary months. First, in the space of three years, they made up an entire month to be intercalated every third year, out of the eleven odd days in every solar year; but, because this artifice was not exact enough, in every eight years they intercalated three months, every one of which consisted of thirty days, (namely,

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(namely, at the end of the third, fifth, and eighth year, though some others in a different manner) and at last, eight months in nineteen years. Hence it is evident, that some of these years are simple, that is, of three hundred and fifty-four, or three hundred and fifty days; the number that there is in the wandering lunar year; some intercalary, of three hundred and eighty-four, or three hundred and eighty-five days, when there are thirteen lunations in the year. These luni-solar, or fixed lunar years, are used by the Jews, and the clergy of the Roman communion.

There are three sorts of solar years, or such as are fitted to the motion of the Sun alone, and the vicissitudes of the seasons depending thereon, viz. the Egyptian, Julian, and Gregorian.

The Egyptian year consists of three hundred and sixty-five days, which they divided into twelve months of thirty days each, and five other days were added at the end of them, as was before observed. In the constitution of this year, there is no regard had to the motion of the Moon; but because this year wants five hours and forty-nine minutes, or almost six hours of the solar-tropical year, in four years time it gets near a whole day before the solar-tropical one, and in one thousand four hundred and sixty years its beginning wanders through all the seasons of the year; on which account it may, in a manner, be called a wandering year, although in the age of one man, or sixty years, it does not anticipate above fifteen days.

Julius Cæsar, finding the Egyptian year to get before the tropical, because the six hours, whereby it wants of the tropical, are entirely neglected in its constitution, did therefore add those six hours to each Julian year; so that a Julian year consists of three hundred and sixty-five days and six hours: and, because this piece or quarter of a day could not be considered or taken notice of in civil affairs, he added the day made out of them in four years to every fourth year, between the twenty-third and twenty-fourth of February, (for the Romans, while they used the lunar year before Cæsar's time, intercalated the ebolimean month) therefore, from that time, they wrote, *Bis*

sexto

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Idus kalendas Martii, or the sixth of the kalends of March twice, from which custom that year had the name of *Bissextile*.

This Julian year, consisting of three hundred and sixty-five days, and adding in four years one day, so that after three simple years there may follow a fourth of three hundred and sixty-six days, is the best fitted for astronomical calculations, because it is a mean between the natural or tropical year of three hundred and sixty-five days, five hours, and forty-nine minutes, and the syderial year of three hundred and sixty-five days, six hours, and ten minutes, and does, as it were, give an ocular demonstration of the natural regress of the equinoxes.

This form of the year was held common among all polite nations from Augustus, who restored it when it was almost lost, unto the year 1582, when the Julian kalendar was reformed by Gregory XII. It must, however, be confessed, that the quantity of the Julian year is too big, on which account the beginning of this year also, by little and little, creeps forward, in regard of the seasons, or, which is all one, the times of the equinoxes and solstices creep backward in regard of the days of this year; and, since this regress is about ten minutes and forty-eight seconds every year, in about one hundred and thirty-three years it will be about one day; and, consequently, from the year of Christ 325, wherein the council of Nice was held, to the year 1582, wherein the pope reformed the kalendar, viz. one thousand two hundred and sixty years, this regress was about ten days. Hence it came to pass, that whereas in the time of the Nicene council, the vernal equinox happened about the twenty-first of March, in the year 1582 it was found to have crept up to the eleventh of March. That he might therefore bring the equinox to its former place, ten days were suppressed in the month of October, in the year 1582, and the fifth day was called the fifteenth: by this means, what would have otherwise been the eleventh day of the March following, and the time of the equinox, becomes the twenty-first of March, that is, the equinox happens the same day, viz. the twenty-

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twenty-first of March, as it did in the time of the council of Nice, which settled the time of keeping Easter. Still, if no other reformation should be made, but the taking away these ten days, the cardinal points would again remove after the former manner, in some years time. The pope therefore, to avoid this, ordered, that once in one hundred and thirty-three years (in which time the excess of a Julian year above the tropical arises to a whole day) one day should be taken away from the kalendar; that is, that three days should be taken out of four hundred years; and this he appointed to be done, by making every hundredth year of the Christian æra common, which, according to the Julian account, is always *Bissextile*; but every four hundredth was to continue *Bissextile*, as in the Julian.

As the form of the year among different nations is various, so likewise is its beginning. The Jews begin their ecclesiastical year with the new-moon of that month, whose full-moon happens next after the vernal equinox. The church of Rome begin their year with the Sunday that falls upon the said full-moon, or that happens next after it, or with the feast of the resurrection of our Lord, which was the custom in France before the year 1564. The Jews begin their civil year with the new-moon, that has its full-moon happening next after the autumnal equinox. The Grecians begin their year with the new-moon that happens next after the summer solstice; and the Romans anciently began theirs with the new-moon next after the winter solstice. This, indeed, seems to be the reason why Julius Cæsar did not fix the beginning of his year, (though a solar year) in the winter solstice itself; but tarried for the following new-moon, where he might place the beginning of his year on the kalends of January, according to the custom then received; though, perhaps, the ancient opinion was not yet entirely lost, that the solstices were celebrated in the eighth part of the signs of Cancer and Capricorn, and not in the very beginning of the signs: by which no more was meant among the learned, than that the Sun
was

was really in the eighth parts of the signs, when he was commonly thought to be in the beginning, which is all one as to say, that the equinoxes and solstices were anticipated for six or seven days; and, if the Sun had been in the first point of Capricorn on the twenty-fourth of December, he would be exactly enough in the eighth degree of it on the first of January. By this method he brought it about, that the celebration of the Olympic Games should fall upon the first day of the month *Quintilis*, which he called after his own name, July: and perhaps these games themselves were by ancient rite instituted on the account of the summer solstice.

The Julian, or old stile as it is called, was used in England till September, 1752, when the Gregorian, or new stile, took place, as it does in most other Christian countries of Europe: and this was the reason of that difference of eleven days between our computation and that of foreign nations; for, as was before observed, pope Gregory, when he set about reforming the year, ordered ten days to be suppressed; and as, in consequence of his new form, another day was struck out of the kalendar at the end of the seventeenth century, this makes in all eleven days, the present difference between the new and the old stiles.

The more celebrated collection of years or times, measured by a repetition of years, are an olympiad of four years; a lustrum, of sometimes four, sometimes five years; a jubile, of forty-nine or fifty years; a *seculum*, or an age, of one hundred years; an *annus magnus*, or great year, standing for an entire apparent revolution of the fixed stars, till, after having departed from a fixed point, they return to the same again, which is twenty-five or twenty-six thousand years, or thereabouts.

C O N C L U S I O N.

HAVING, in the preceding chapters, endeavoured to explain the motion, magnitudes, &c. of the heavenly bodies, we shall now, by way of conclusion, shew some of the advantages arising from their present order and disposition.

When we attentively survey the works of the creation, what a beautiful scene of things is presented to us! How simple, and yet wonderful, are the works of nature! Such like are all the effects of infinite wisdom: her foundations are plain and simple, but her superstructures are various and wonderful: her causes few, her effects innumerable: her course the easiest and shortest, and her means the fewest that can possibly bring about her ends. How beautiful and glorious a body is the Sun, and of what absolute necessity to the being of all animals and vegetables! As to vegetables, it is beyond all doubt, that without the Sun they could never rise above the ground; for it is his heat alone, that rarefies the fizy juices about their tender roots, and makes them force their way, to display all the foldings of the slender seed, and thereby to augment their parts, just as we find his heat raises the liquor in the thermometrical tubes, and drives them through all its winding branches: and though, perhaps, animals might make a sorry shift (supposing food could be supplied them without his influence) in a perpetual state of darkness, yet it would be a very miserable sort of life, and could be of no long continuance; for we know how necessary the Sun is to purify the air, and to exhale the noxious dews, and the baleful vapours of the night: we feel a sensible joy in his light, and heaviness in his absence; foul weather, and a cloudy day, is a disease alone; and they who understand the animal economy, know the reasons, and the mechanical necessity of all these things: one thing every one knows, viz. that by the heat of the Sun, and the action of his rays, that infinite

finite number of the excretory ducts of perspiration, placed along all the superficial parts of the body, are more freely and plentifully derived, which must needs give a greater freedom to the blood and spirits; the contrary of all which happens in the absence of this benign star.

What an instance of wisdom and contrivance in the great Creator is the placing of that fountain of life and light, the Sun, in the centre of his system! how unartful would it have been to have set him in a corner, when he was to have given light and warmth to all the bodies round him! Besides, to the conservation of any such supposition, such as the * Tychonic or † Ptolemaic, there are required so many different laws of gravitation, that any reasonable person, by inquiring into them, would easily discover, that this position of ours was the most simple and easy, and looked most like the effects of wisdom and design: for here one single law accounts for all the various motions and appearances of the celestial bodies. Thus, then, this glorious body of the Sun is fixed, like a powerful and kindly monarch on his throne, distributing light, warmth, and life, in plentiful effusion, to all his surrounding vassals, and that so equally, that the nearest have not too much, nor the remotest too little. These are such great, such wise ends, as clearly speak the omnipotence and omniscience of their author.

Let us consider, with how much artfulness his bulk and situation, in respect of the planets, is contrived to have just quantity enough of matter to draw round him these massy bodies and their satellites, so various in their bulks and distances from him, and that in regular and uniform orbits; how exactly his body is rounded, how fully it has been saturated with the fluid of light, to be able to last so many years, without any sensible diminution, though there are constant emanations thereof upon his attendants.

As for the rotation of the Sun about his own axis, it is no doubt, likewise, for wise ends and purposes;

See Plate I.

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perhaps it may be for the better propagating and emitting this fluid of light through the planetary regions; though the great and learned Dr. Cheyne is rather inclined to believe, it may be the necessary effect of the fluidity of his body, it being very well known, that the particles of all solid bodies running into fusion, by the force of the heat, are turned innumerable different ways; and thus, by their oppositions and interferences, are at last determined into a circular motion of the whole one way. However this matter may be, we have here sufficient instances of wisdom and design, to enforce upon us the belief, that a being infinitely perfect is the author thereof.

We can no otherwise gather the usefulness of the secondary planets to their primary ones, but by supposing the rest may reap respectively something analogous to the benefits we, the inhabitants of the Earth, receive from our Moon, the principal of which is, the supplying the deficiency of the Sun in the night time; for at least three fourths of the year. How comfortable and delightful a thing this is, travellers and voyagers can best tell. Curiosity, ambition, or luxury, have now made it necessary, that some part of mankind should be travelling by land or sea in the night seasons: how pleasant, then, and joyful a thing, it is to have a light held us forth from heaven, not only to guide our steps, but to direct us in our course, and to point out to us how our time slides away! for a very little experience makes us reap both these last advantages from the presence and motion of the Moon.

The Moon raises our tides twice in twenty-four hours, which how absolutely necessary it is for the subsistence of animals and vegetables, we shall now shew. Every one knows, that a lake, which has no fresh water running into it, will, by the heat of a few months, and its stagnation, turn into a stinking rotten puddle, sending forth nauseous and poisonous steams; for, though it is not probable, that the constituent particles of water themselves are altered by this stagnation, yet no water is absolutely pure, but contains
a greater

a greater quantity of fleshy, bony, earthy, saline, metallic, and vegetable particles, than of pure elements; and it is upon these the heat operates, by dissolving their union, and combining them in new forms, and separating those noxious particles, which produce this effect.

Though there be many thousands of fresh-water rivers daily running into the sea, yet they are very inconsiderable in respect of the vast ocean of salt water, and would by no means hinder its stagnation, and consequently its corruption and stinking. But admit the ocean once stagnated, then the first effect would be, that all the places towards the shores would be the first wrought upon by the action of the Sun, and turned into a putrid state; and then, by degrees, it would get farther, till the whole were become more baneful and poisonous than the lake of Sodom and Gomorrah; by which the fish would be first destroyed, and, by the noxious steam thence arising, afterwards the plants and animals: whereas, by this action of the Moon, the waters are lifted up in an heap, as it were, and then let fall again; by which the waters near the shores are constantly secured from stagnation and corruption, and the malady stifled in its beginning.

This perpetual change of new water on the shores, keeps any one portion thereof too short a time exposed to the heat of the Sun, to have its mixture corrupted. What a noble contrivance have we here! By appointing an attendant to our Earth, all the vegetables and animals are preserved from certain destruction. Besides this, how many conveniencies for our navigation, in rivers and harbours, does this ebbing and flowing of the sea afford! And here, perhaps, it will not be amiss to observe, that if our Earth had any more than one Moon attending it, that we should receive more damage than advantage from it: for though, perhaps, our light thereby in the night (provided she were of any bulk, or at any distance near to that of our present Moon) might be augmented; yet, at the conjunctions and oppositions with one another, and with the Sun, we should have tides that would raise the waters

waters to the tops of our mountains, and in their quadratures we should have no tides at all. In short, if our Moon were bigger, or nearer the Earth, or if we had more than one, at any tolerable distance from us, we should be every now and then in hazard of being drowned; and if our present Moon were less, or at a greater distance, or if there were none at all, we should be in danger of being stifled by the noxious steams arising from the ocean, which would stagnate much more than it now does: from all which it is evident, how wisely our satellite has been contrived for our purposes.

As for the numerous attendants of Jupiter and Saturn, they must be reasonably expected to fit the necessities of the inhabitants of these planets, since our Moon suits us so well; and, though the fluids of these planets be not in so great hazard of corrupting from the heat of the Sun, yet they may possibly be in hazard of being congealed by the violence of the cold, and the frequent tossing and turning over of them, by the united or separated forces of so many moons, may hinder this effect: for we sufficiently know, how strongly fluids in motion will resist the efficacy of cold. However the thing be, we may here observe one signal instance of wisdom and contrivance, in placing the heavenly bodies at such a distance from each other, and especially the greatest at the greatest distance; for, had they been situated much nearer to one another, they would have caused prodigious disorders in very different manners, and in particular such destructive tides, wherever there was any quantity of fluids, or great oceans, that neither animals nor vegetables would have been able to sustain their fury, which, by this prudent placing the heavenly bodies at such a distance from one another, are entirely prevented.

As to the comets, we have little more to say concerning them, than what has been already said: their nature, orbits, motions, &c. have been so lately determined, and there are so few accurate observations about them, that we have scarce any solid foundation to build our reasoning upon.

Dr. Cheyne is of opinion, that "these blazing stars are not designed for the habitation of animals in a state of happiness, nay, even scarce of animals not under a state of punishment: they may be the first rudiments of planets not yet brought into our system, or rather the ruins of some banished thence, to wander in those long eccentric orbits through the world."

"But most likely (continues the same author) they are the ministers of Divine justice, sending baleful steams from their long tails upon the planets they come nigh; and, if what is commonly said of them by astrologers be true, they seldom visit us without some such direful salutation: however, from them we may learn, that the Divine vengeance may find a seat for the punishment of his disobedient creatures, without being put to the expence of a new creation." This is the opinion of that learned author, above quoted, concerning comets; which is, indeed, very different from what we have before mentioned on this head: whether the opinion of Dr. Cheyne, or that advanced by some modern writers, whom we have followed, in Chapter VI. be the most probable, we will not presume to say, but shall leave abler heads to determine.

We come now to enquire into the wisdom of the contrivance of the planets. Having already shewn the analogy between them and our earth, and how probable it is, that they are inhabited by creatures fitted for such habitations, we shall content ourselves with pointing out some of the most considerable instances of design and wisdom in this our planet; hoping our fair readers will reason after the same manner (bating particular circumstances) of the rest; and that both because the designed brevity of this treatise will not permit us to be so particular as the subject deserves, and because if the analogy holds in general, the particular ones (with allowance for circumstances) will easily follow.

First, let us consider the advantages arising to us by the rotation of the earth about its own axis. We, the inhabitants of this globe, are so made, that, once in sixteen or twenty hours at most, we require a time

for relaxation; and, generally speaking, in all healthy people, this time is pretty equal, between six and nine hours: the store-houses of our spirits will not permit any longer application than eighteen or twenty hours, without injury to our constitutions, and much about the time of six hours is required to fill them again: indeed, it is necessary, that an alternation of application and relaxation should be once in twenty-four hours. It is true, custom may get the better of these natural propensities, and a very strong constitution may bear out with harder measures for some time; but the young and the weak, and almost all at their own liberty, naturally run into a relaxation, and recruiting their spirits by sleep once in twenty-four hours. It was likewise necessary, that the air should be at least cool and temperate during the time of this rest; for we generally find those that sleep in the open air, or even while the Sun is above the horizon, the worse for it, the Sun and heat exhaling the natural perspiration too violently, and raising too quick a motion in the blood, whereby the sleep is less calm and more disturbed. Though we generally perspire more in the night than the day, yet this is more natural, less violent, and more according to the necessities of our constitutions, in the night than the day; besides that, consequently, the darkness is less subject to noise than the day.

Now all these things are wonderfully provided for by the rotation of the earth about its axis; for thereby we have the vicissitudes of day and night; the day for application to the toils of business, in which we spend our spirits, and the night, by its coolness and quiet, to afford us time to recruit them, and lay up in store for the expenses of the next day; as also for nourishing the muscles, bones, channels, and the other parts of the body: for the business of nutrition is mostly, if not altogether, performed in the time of rest; because the blood has too rapid and quick a motion, and the expences of the spirits are too great, to afford leisure or materials for nourishing the parts in the time of application: besides, a gentle, uniform motion

is required to apply nourishing parts to the necessary places, and to settle them there; and we generally find, that people recovering from a disease, and children, sleep more, and are more fed by their sleep, than by any other animal function, and gross people naturally sleep longest.

What a comfortable and refreshing thing is the cool breeze of the night to those that live under the equatorial parts, without which life would be there both exceeding short and very grievous!

Let us reflect upon the necessities of our vegetables, which are the support of animals. We have before observed, that the heat of the Sun rarefies, and consequently raises the fizy juices at the roots of the tender seeds, and thereby forces the folded branches to expand and enlarge. Now, were the Sun constantly, or for any long time, shining on them, these juices would not be at liberty to settle and consolidate in the fit places of the branches, but would be still rising higher, till at last they would burst the tops of the canals, and consequently would produce nothing; whereas, by this vicissitude of heat and cold, what is raised in the day-time has time to settle and consolidate in the night, and its cold runs its thin juices first into thick, fizy substances, which the supervening heat, by exhaling the watery parts, which are now brought nearer the surface of the plant, hardens and fixes. This we evidently see in nutgalls, and the other excrescences of the leaves of vegetables; and, generally, countries that have moderately cool nights, produce vegetables of the firmest union of parts; and very hot countries suddenly bring up their seeds, but their parts are less firmly stuck together: they may be heavier, but not so tough or hard; though this, too, depends much upon the constitution and first make of the seed.

On the other hand, had not the earth moved upon its axis, but only turned round the Sun in its annual period, we had not only lost all these advantages, which are so beneficial, if not absolutely necessary to the being of our animals and vegetables, but we had suffered also such inconveniencies, as neither of these

could possibly bear; for then, during near one half of the year, we should have been in perpetual darkness; the consequence of which would have been, that baleful and sulphureous damps (by the force of the preceding heat generated and raised) would have fallen, which would have stifled all the animals; or, had they survived that, by degrees, excessive rains would have poured down, (as the vapours became cooler) next sleet, then snow, and ice, and frost, which would, of necessity, not only have locked up all fluids, but would have freezed the blood and spirits in the channels of all the animals we are acquainted with; for there is a saline body constantly swimming in our air, which, by the presence and action of the Sun, is so attenuated and reduced into slender particles, whose points, being easiest broken by the force of the fluid of light, are first beat off, as not to be able to do any damage; but, in his absence, they shoot themselves into oblong sharp wedges, which stick together the parts of all bodies. Now, in half a year's absence of the Sun, in what quantities, and with how much firmness, would these saline bodies have formed themselves! Certainly, nothing that moves, whether animate or inanimate, would have been able to support such a cold. All this is plainly demonstrable, and actually happens in those places that are under the poles, during a much shorter absence of this glorious star.

Again, in the enlightened half of the year, we should have had, first huge deluges of melted waters from the preceding snow, which likewise would have produced suffocating mists; next, all our grounds would have been turned into a stiff, stinking puddle, being in a manner dissolved by the force and quantity of the snow-water; then would sultry heats, and a burning air, have galled us, that we should have found rest neither in houses nor dens, till at last the heat encreasing without abatement, the blood and spirits of all the animals of our globe would be quite exhaled, or they turned delirious by the violent agitation of the blood and spirits, and then died in convulsions; for it were absolutely impossible, that any thing that has life should resist such a degree of heat.

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It is true, there are some people live under the equator, yet they have but a very uncomfortable time of it, notwithstanding they are supplied with constant breezes, arising from the Earth's rotation about her axis, and prodigious quantities of rain, falling by the plenty of vapour, raised by the day's heat, and let fall by the supervening cold of the night, having as long a night as they have a day, which is a very considerable relief, the continued uninterrupted action of the Sun being by much a far harder part than the degree of the heat at stated seasons. And, as for the poles, we have very certain information, that few, if any at all, inhabit near them, the extreme degrees of heat and cold that happen there being incompatible with an animal life. But that which would make the case much worse than it now really is in the most unfavourable part of our globe, upon this supposition, is, that the rays of the Sun would be direct, and there could be no rains nor winds, because it is the cooling of the air that is the cause of both, which by no means could happen in our case, every succeeding hour heating the air to a greater degree than the former. Add to all these, that our seas, even notwithstanding our tides, would either be exhaled, or turned into deserts of salt; and so, not only all the fish would be destroyed, but we could have no fresh water, seeing we could have no cool air to send it down. If we had any plants or vegetables, they would be but of one particular kind, viz. those which require the greatest degrees of heat: but it is demonstrable we should have occasion for none; for any one, who understands the animal oeconomy, will easily see, that no animal, such as we have on our globe now, could bear such an excessive and uninterrupted degree of heat. Upon all which accounts it is very plain, that the present rotation of the earth about her axis, is one of the most signal instances of wisdom and contrivance that can be imagined.

Let us now combine this diurnal rotation of the Earth about its own axis, with the annual revolution of the same about the Sun, and the parallelism of the axis of the diurnal rotation with itself; and
from

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from hence we shall have the beautiful seasons of the year, seed-time and harvest, summer and winter, the comfortable vicissitudes of colder and warmer periods, of snow and rain, winds and calms, of shorter days and longer nights, and again of longer days and shorter nights, and of all those delightful changes, which are so pleasant, comfortable, and necessary in our present circumstances. If the Earth had only turned about her own axis once in twenty-four hours, then all our vicissitudes would have been of days and nights, which by no means would have been sufficient for vegetation. If the Earth had made a period about the Sun once in the year, without any rotation, we should have had but one long day and an equal night, which, as was before shewn, would not have agreed either with life or vegetation. If both these had been united, without the third of the parallelism of the axis of the diurnal rotation to itself, we might have had days and nights, but our other seasons would have been uncertain, and in some places none at all: thus the effects of the annual revolution would in some measure have been destroyed. By this wise conjunction of all these three modifications, we enjoy our seasons, and the other consequent changes of the year, which are of so great use to us; for, had we enjoyed a constant uniform season all the year round, suppose of summer weather, then our ground had been exhausted and worn out, by constant bringing forth of vegetables, and would have run into weeds; and those other plants, which require the least rich soil, and most heat only: so that, in a few years, the Earth would have been reduced into a wilderness of unuseful herbs; since that, towards the production of the more useful plants, there is required, besides a certain degree of heat and moisture, a lixivial and nitrous salt, which keeps the mould loose for receiving the moist air, and for the entry of that heat and moisture: for, though salts consolidate water, which consists of solid, porous parts, whereby their particles are stuck together, yet they keep the parts of mould or sandy clay, which has little or no water, asunder and loose, by the very same reason; for their particles not allowing them

them entry into themselves, they get between them, and first separate their union, and then keep them from coming together, and perhaps both forward the motion of the liquors in the vegetable channels, (which are certainly endowed with some degree of elasticity, and so capable of being stimulated, as is evident in younger twigs and branches, as well as animal ones) and endows the juices with the qualities the plant requires.

These salts are either quite exhausted or destroyed by constant vegetation. We see the best ground wears out in a few years, and turns into wild useless weeds; and all the materials for enriching ground are gathered from places debarred from the action of the Sun, and the expences of vegetation, but exposed to the air and weather, whereby they are impregnated with this nitrous salt; such are old turf, new mould, the dung and excrements of animals, or those things which abound with lixivial salts; such are burnt wood, burnt turf, stubble, and the like. Now all these would, by a short time's uninterrupted vegetation, have been quite spent. Add to these, that in a perpetual summer, there would not fall sufficient quantities of rain to moisten and soften the mould, to that degree which is necessary for constant vegetation; for we find there is much more rain falls in the winter six months, from September to April, than in the summer six months; and yet all this is but sufficient for one six months vegetation.

Again, even the animals themselves could not conveniently bear a perpetual summer; for we now find, that the cold of the winter, by stopping the pores of the sensible perspiration, keeps the warmth more within, whereby there is a greater quantity of spirits generated, the blood is less rarefied, the natural functions are more strong, and performed with more vigour; the digestion is better, the sensible excretions more natural and less violent, and the crudities of the preceding summer are settled and digested; that is, in healthful and sound animals, (for the case is quite otherwise, as of necessity it must be, in sickly ones) and

and in a moderate and not over-tedious winter: whereas, in summer, the blood is more rarefied, the spirits more exhausted, the sensible perspiration more violent, and less natural, the digestion worse, and all the concoctions less thoroughly performed: so that it is evident, we could bear neither of these states perpetually, the change of the one being absolutely necessary to qualify the errors and extremes of the other. If we had a perpetual summer, we should be reduced to mere skeletons; if a perpetual winter, we should turn dull, inactive drones.

Perhaps, against all these it may be objected, that there are rational creatures who inhabit this globe of ours, who are perpetually in both these extremes, and yet are found to be not at all disposed as is above pretended. To this may be answered, that though, as to the presence or absence of the Sun, they may be much the same as we suppose, yet there are other concurring circumstances, which arise from the vicissitudes of the seasons in the other parts of the globe, which alter the case quite; for there are constant seasons of rain in the more southern countries, which fall for some considerable time, that both hinder the perpetual vegetation, soften the mould, and fatten it for the next crop: there are clouds of snow and rain, impregnated with these nitrous salts, which are driven, by the force of the winds, from colder into these hotter countries, and there falling, enrich the ground. Besides that, even the clouds, raised from these hotter countries themselves, when distilled into rain, are sufficient for this end; for, as was before observed, the air every where is full of such salts, as is known by experiment. Let any one consult Varenus, and he will be satisfied, that these southern countries have winters, though not of snow; yet what is abundantly sufficient to stop the perpetual vegetation, to moisten, soften, and fatten the mould, and to cool the blood, and other fluids of the animals.

The principal thing that renders the state of a perpetual summer unfit for the present constitutions of the animals and vegetables, is, that in such a state, arising

arising either from only a diurnal rotation, without an annual, or an annual without a diurnal, there would not be that variety of cool rains, and cool breezes, nor constant and trade-winds, nor over-flowing rivers, and such like circumstances, which are the effect of this combining these two motions together.

We need not shew the inconveniencies of a perpetual winter; every one is sufficiently sensible, that, upon such a supposition, we should have neither vegetable nor animal in a very short time. As for spring and autumn, they are not so much distinct seasons from the former, as gentle gradations, whereby the one slides into the other, through the intermediate degrees.

Hence it is evident, how wisely these three so different modifications have been linked together, for the benefit of the inhabitants of this globe; for by these we have sufficient heat in the summer, to ripen the fruits that are the product of every respective climate, and we are furnished with reason, and made capable of industry, to transfer the products of one country to another. We have rain and cooling breezes in the winter, in those countries where heat is not wanting, to cool, soften, and enrich the mould, and to stop constant vegetation; and we have frost and snow in others, where the heat is not abundant, to lock up the mould from being washed away, and to keep in either the natural or adventitious heats, till the time that all circumstances concur to have the product of the ground brought to its vegetation.

We shall now proceed to consider the obliquity of the plane of the ecliptic to that of the equator, or of the axis of the diurnal rotation to the plane of the annual orbit of the earth. We have already shewn, that if the equator and ecliptic had coincided, it would have rendered the annual revolution of the Earth quite useless; for, if the Earth had moved about its own axis, and this axis had been at right angles with the plane of the elliptic, the same appearances, as to the vicissitudes of night and day had happened, whether the earth had moved round the Sun or not; but the alterations of seasons, and all the consequences thereon

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thereon depending had not been at all; and what a hindrance this would have been to life and vegetation, we have already shewn. Besides, in the torrid zone, the heat would have been intolerable, and not to have been endured; and, in the frigid zone, the cold would have destroyed both animals and vegetables, and even in the temperate climates, the one half of them would have made but a very comfortless habitation for such creatures as we now are: so that but only the other half would have been, by any means, a tolerable seat for rational creatures, and five sixths at least of the whole globe would have been rendered useless. But the Almighty, who is wiser than man, has contrived the matter much better; for, by this present obliquity of the ecliptic to the equator, we reap one very considerable advantage, viz. that we, beyond the forty-fifth degree of latitude, and who consequently have the greatest need of the Sun's heat, have more of it, take the whole year round, than if the Sun had moved continually in the equator; and they that live in the torrid zone, and the adjacent places, even to the latitude of forty-five degrees, who are rather too much exposed to the heat of the Sun, than too little, have, by these means, less of his heat than they would have had, had the Earth observed a right position.

To these add, that since this globe of ours has been designed for an habitation of rational and irrational creatures, of various tempers, constitutions, and dispositions, and for vegetables of different natures and virtues, requiring different degrees of heat and nourishment, to ripen and bring them to perfection, to shew the manifold wisdom of the Author of Nature in the variety of every thing; and since we find the present heat of the torrid zone very well fitted for all the kinds of animals and vegetables that inhabit and grow there; the cold of the frigid zones very tolerable to the inhabitants and productions of these places, and the temper of the intermediate ones suited to theirs, those animals that cannot transport themselves, and the vegetables that require a greater degree of heat, not having too much, and the like

animals and vegetables that can suffer cold not having too little heat, and the rational creatures being endowed with reason and means to transport themselves where they live most at ease; and since it was impossible to have accommodated all these so various and different animals and vegetables in a place of an equal and uniform, or in one and the same, climate, it is evident, that the present situation of the axis of the Earth to the plane of the ecliptic, is the best of that infinite variety possible, that could be for our present circumstances; for, by any other very considerable alteration, all or most of the above-mentioned advantages would be lost. For all which reasons we can never sufficiently admire the wisdom of the Author of Nature, who has provided so liberally and prudently for his creatures.

The same divine wisdom is conspicuous in the situation of the Earth in respect of the Sun; for, had the distance between the Earth and the Sun been the same with the distance between Mercury and the Sun; that is, were we brought three times nearer the Sun than we are, or the Sun brought three times nearer us than he is, our ground in winter would have been hotter than red-hot iron, and what a condition we should have been in then we may easily guess. On the other hand, had the Sun been removed from us, or we from the Sun, to the distance Jupiter or Saturn are removed, our hottest summer-day had not afforded us so much heat as those which now live under the very polar star (if any such there be) of our globe feel in the midst of winter: are not we then very wisely provided for, who are put in such a mediocrity, between these two extreme distances, that neither our heat nor cold is so violent, but that we may either endure them, or, with a little industry, fence ourselves against their injury?

As to the figure of our Earth, though it be the necessary result of the Earth's rotation about its own axis, and the fluidity of the superficial parts of the Earth at the commencement of this rotation, yet it is very convenient for us. By the Earth's motion about its axis, the parts endeavour to recede from the same axis

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as much as they possibly can, by a centrifugal force arising from the circular motion; and therefore, if the matter of any of the heavenly bodies was fluid at the commencement of this circular motion, it would necessarily have arisen from the poles, and accumulated at the equator, and so induced a spheroidal figure on the planet's body, generated by the circumvolution of an ellipse about its lesser diameter.

It is evident from the figure of the Earth, that the surface of the temperate climate is larger than it would have been, had the globe of our Earth been either spherical or oblongly spheroidal: so that the advantage of this figure is very considerable. The surface of the polar regions, which, by reason of the oblique incidence of the rays of the Sun upon it, is colder, and less convenient for the habitation of animals, and the production of the nobler sort of vegetables is hereby considerably lessened; and the surface or space about the temperate zones, which are more comfortable and useful, is thereby considerably enlarged.—How bountiful is the hand of our Creator! How amazing are all his works!





BOOK II.

Of the Atmosphere, Light, and Gravity
of the EARTH, &c.

CHAP. I.

Of the Atmosphere in general.

HAVING mentioned in the preceding book, that the Earth is surrounded by an atmosphere, we shall in this proceed particularly to describe its nature and make.

The atmosphere is composed of a mass of air, of subtile, penetrating matter, fit to pervade other bodies, to penetrate into the inmost recesses of nature, to excite, animate, and spiritualize, and, in short, to be the soul of this lower world. "The air (says Seneca) is a part of the world, and indeed a necessary part, since the heavens and the earth are connected by it." It is the fountain of life and health, and of every pleasure and enjoyment. It is the air the whole animal world breatheth, and liveth by; not only the animals inhabiting the earth and air, but those of the waters too. Without it most animals live scarce half a minute; and others, that are most accustomed to the want of it, live not without it many days.

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As the air is of absolute necessity to animal life, so it is necessary that it should be neither foul, nor too rare and thin; in the former case it would suffocate, and, in the latter, would not be sufficient.

It is certain, that fresh air is absolutely necessary, since pent-up air, when overcharged with the vapours emitted out of animal bodies, becomes unfit for respiration; for which reason, in the diving-bell, after some time of stay under water, they are forced to come up and take in fresh air, or by some such means recruit it. But the famous Cornelius Drebbelle contrived not only a vessel to be rowed under water, but also a liquor to be carried in that vessel, that would supply the want of fresh air. The vessel was made for king James I. It carried twelve rowers, besides the passengers. It was tried in the river Thames, and one of the persons that was in that submarine navigation was then alive, and told it to a person, who related the matter to the famous Mr. Boyle. As to the liquor, Mr. Boyle says, he discovered, by a doctor of physic, who married Drebbelle's daughter, that it was used, from time to time, when the air, in the submarine boat, was clogged by the breath of the company, and thereby made unfit for respiration, at which time, by unstopping a vessel full of this liquor, he could speedily restore to the troubled air such a proportion of vital parts, as would make it again, for a good while, fit for respiration. But that wonderful quality in this liquor is much doubted.

As too gross, so too rare, an air is unfit for respiration; for it is found, that even the extraordinary natural rarefactions, upon the tops of very high hills, much affect respiration. An ecclesiastic, who had visited the high mountains of Armenia, (on which some fancy the ark rested) told the great Mr. Boyle, that, whilst he was on the upper part of them, he was forced to fetch his breath oftener than usual; and, taking notice of it when he came down, the people told him, that it was what always happened to them when they were so high above the plane. The like observation the

the same ecclesiastic made upon the top of a mountain in the Cevennes. In like manner, a learned traveller and curious person, on one of the highest ridges of the Pyrenees, called *Pic de Madi*, found the air not so fit for respiration as the common air, but that he and his company were obliged to breathe shorter and oftener than in the lower air.

Such another relation the learned Joseph Acosta gives of himself and his company, that, when they passed the high mountains of Peru, called the *Cordilleras des Andes*, (to which, he says, the Alps themselves seemed to them but as ordinary houses, in comparison to high towers) he, and his companions, were surprized with such extreme pangs of straining and vomiting, (not without casting up of blood too) and with so violent a distemper, that he concludes he should undoubtedly have died, but that this lasted not above three or four hours, before they came into a more convenient and natural temperature of the air; all which, he concludes, proceeded from the too great subtilty and delicacy of the air, which is not proportionable to human respiration, and which requires a more gross and temperate air.

Thus it appears, that an air too subtile, rare and light, is unfit for respiration: and, as our inability to live in too rare and light an air may discourage those vain attempts of flying, &c. so our being able to bear an heavier state of the air, is an excellent provision for mens occasions in mines, and other great depths of the earth.

That the inhabitants of the air, birds and insects, need the air as well as man, and other animals, is manifest from their speedily dying in too seculent, or too much rarefied air; but yet birds and insects, some birds at least, can live in a rarer air than man: thus eagles, kites, herons, and divers other birds, that delight in high flight, are not affected with the rarity of the medium, as Acosta, and those before mentioned, were.

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1. Creatures inhabiting the waters need the air, as well as other animals, and, indeed, fresh air too. The hydroconthari of all sorts, the nymphæ of gnats, and many other water insects, have a singular faculty, and an admirable apparatus to raise their back parts to the top of the water, and take in fresh air.

So fishes also are well known to use respiration, by passing the water through their mouths and gills; but carps will live out of the water only in the air, as is manifest by the experiment in their way of fattening them in Holland, and which has been practised here in England, viz. they hang them up in a cellar, or some cool place, in wet moss in a small net, with their heads out, and feed them with white bread, soaked in milk, for many days.

Not only animals themselves, but even trees and plants, and the whole vegetable race, owe their vegetation and life to this useful element, as is manifest from their glory and verdure in a free air, and their becoming pale and sickly, and languishing and dying, when by any means excluded from it. Thus useful and necessary is the air to the life of the animated creatures, and no less is it to the motion and conveyance of them. All the winged tribes owe their flight and buoyance to it; and even the watery inhabitants themselves cannot ascend and descend into their element without it. Fishes, by reason of the bladder of air within them, can sustain or keep themselves in any depth of water; for the air in the bladder being more or less compressed, according to the depth the fish swims at, takes up more or less space; and, consequently, the body of the fish, part of whose bulk this bladder is, is greater or less, according to the several depths, and yet retains the same weight. Again, a body that is heavier than so much water, as is equal in quantity to the bulk of it, will sink; a body that is lighter will swim; and a body of equal weight will remain in any part of the water. By this rule, if the fish, in the middle region of the water, be of equal weight to the water, that is, commensurate to the bulk of it, the fish will rest there, without

out any tendency upwards or downwards; and, if the fish be deeper in the water, the bulk of the fish becoming less by the compression of the bladder, and yet retaining the same weight, it will sink and rest at the bottom. On the other hand, if the fish be higher than the middle region, the air dilating itself, and the bulk of the fish consequently encreasing, but not the weight, the fish will rise upwards, and rest at the top of the water. Perhaps, the fish, by some action, can emit air out of its bladder, and, when not enough, take in air; and then it will not be wondered, that there should be always a fit proportion of air in all fishes to serve their uses. It has been observed, that if the swimming bladder of any fish be pricked or broken, such a fish sinks presently to the bottom, and can neither support or raise itself up in the water.

The structure of the air produces other effects, equally surprising with those already mentioned. The air informs us, with as much punctuality as expedition, from every side, and that at a considerable distance too, of every thing that any ways relates to us, whether good or bad. It is the vehicle of smells; by the transportation of which to us we are acquainted with the good or ill qualities of the food that is set before us; and as, on the one hand, it intimates, by several delicate and tempting sensations, what is wholesome and fit for our use, so, on the other hand, it as faithfully forewarns us, by some quick and disagreeable impression, not to touch any thing that is poisonous, to avoid sitting in a place that is damp and dangerous, or entering into a house that is unwholesome or infectious.

If the air acts the part of such a faithful monitor, by the various intimations which it gives us through the mediation of smells, it is equally, if not more diligent and faithful in conveying knowledge to us by the ministration of sounds. These sounds may be properly looked upon as so many couriers, which run for ever backwards and forwards, to bring us news of transactions that frequently occur at a considerable distance from us.

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We form, by the motion of our tongue and lips, a variety of sounds, the different articulations whereof are, by the unanimous consent of all mankind, agreed to be the signs of such and such ideas. By this expedient, our friends, who hear the sounds which are formed in the air by the motion of our lips, are informed of all those ideas which we had entertained, and become fully acquainted with all our thoughts. It is the air, therefore, that is the interpreter of all mankind, and the cement of society.

It not only conveys instruction to those who are inclined to communicate their thoughts in common conversation, but gives timely notice of any imminent danger that threatens such as are at a great distance from one another. As for instance, it is impossible for those who reside within the walls of a city, to see what is transacted in the suburbs; nor can they, who are apprised of the enemy's attack at one quarter, be ever able, let them exalt their voices never so high, to give immediate notice of the danger they are in to their fellow citizens, who reside at another. The proper centinel, however, who, by his commodious situation, can discern the enemy's approach at a considerable distance from the town, gives the signal of distress by a stroke or two on a large bell, and in a second of time, that is to say, the sixtieth part of a minute, the air conveys the sound of it one thousand and eighty feet, all round about the tower. In one second more, the sound is carried the same distance farther; thus, in less than half a quarter of a minute, the whole city is alarmed, and have timely intimation to repair to their arms, and put themselves in a posture of defence.

The air is therefore not only the most speedy, but the most industrious messenger, that can possibly be employed. If, however, we stand astonished at its vigilance and expedition, what idea ought we to entertain of that exactness and impartiality with which it delivers its message? it distributes the harmony of a concert to every ear alike: it never fails to keep the most exact time: it repeats all the gay divisions, con-veys

veys to us the least inflections of the voice, a quarter part of a note, the least variation imaginable of a tone; it runs, in short, through the whole compass of music, and loses no single grace; it swells the sounds, and even makes them thunder in our ears: the next moment it makes them flutter, and melt into dying strains; after this, it swells the notes again, and sinks them in their turns. Thus it expresses, in the most lively manner, every passion of the soul, and every breast is fired by its persuasive sounds.

C H A P. II.

Of the WINDS.

SO great is the use of the winds, and of such absolute necessity are they to the salubrity of the atmosphere, that all the world would be poisoned without those agitations thereof. We find how putrid, fetid, and unfit for respiration, as well as health and pleasure, a stagnating, confined, pent-up air is; and, if the whole mass of air and vapours was always at rest, and without motion, instead of refreshing and animating, it would suffocate and poison all the world: but the perpetual commotions it receives from the gales and storms, keep it pure and healthful.

As wind is a current of air, so that which excites or alters its current, may be justly said to be the cause of the winds. An equipoise in the atmosphere produces a calm; but, if that equipoise be more or less taken off, a stream of air, or wind, is thereby accordingly produced either stronger or weaker, swifter or slower: and many things there are which may make such alterations in the balance or equipoise of the atmosphere, viz. eruptions of vapours from sea or land, rarefactions and condensations more in one place than another, and the falling of rain, pressure of the clouds, &c.

There are some winds which are regular, and others irregular. The former are such as blow constantly in some certain countries, and in one particular latitude:

the latter are such as have no established rule or course, as we can discover.

The most regular winds that we know of, are those which blow, almost all the year round, between the two tropics from east to west; and those distinguished by the appellation of etesian, or annual winds, which blow, when it is summer with us, from the north to the equator; and from the south pole to the equator, when it is winter with us.

From what occurs almost daily in every climate, some short time before the rising of the Sun, we may be enabled to give a rational and satisfactory account of these regular winds. Though at day-break there may happen to be no settled wind, yet according as the Sun draws near to our horizon, and some short time after he is risen, we perceive, for the most part, a pretty fresh easterly gale. Now this easterly gale, in all probability, proceeds from the air's being rarefied in that corner, by the return of the Sun, who drives before him that which is more condensed, and at a greater distance from him. This of necessity causes an easterly wind; but then we find it ceases, in proportion as our air is heated.

By a parity of reason, the same wind must constantly precede the Sun in the torrid zone, and blow brisker there than in our climates, where the action of the Sun is not near so intense. Thus, for the generality, we find, that the wind blows in the torrid zone from east to west, and that the inhabitants there are almost strangers to a westerly wind.

However, as the Sun passes gradually from one tropic to another, when his genial rays advance towards the north, the air of the northern countries begins to dilate itself; but finding a resistance from a body of compressed air, that is still more northern, it must of necessity take its course that way where it finds the least opposition, and turn back to the equator.

The wind must therefore blow from the east in summer, that is, whilst the Sun is on our side of the equator, and from the north to the south; from the former, by the succession of the heat to the nocturnal cold, and from the latter, by the reflection of the rarefied

refied air, which meets with a resistance from the northern air which is more condensed. Hence proceed the trade or annual winds, which bring with them those heavy showers of rain that are so refreshing, and of such singular service to the inhabitants of the torrid zone, who live on this side the equator. The same winds must likewise, by consequence, blow from the south pole, and bring along with them those showers which are so refreshing to the inhabitants of the torrid zone, who live on the other side of the equator, when the Sun passes the equinoctial line, and advances towards the tropic of Capricorn.

Though these general winds may be sometimes obstructed, either by mountains, or some particular wind from another quarter, yet we ought not, from such accidental deviations, to conclude, that they observe no rule or stated course. We are too apt to think many things irregular which proceed from an uniform cause, to which we are perfect strangers.

Local and irregular winds derive their origin and variation from streams of air dilated under ground; from the descent of clouds, and the expansion of the air confined within them; from the various degrees of heat, which bring the wind with it, and of cold, which repels it; in fine, from the different determinations of the air, either reflected by mountains, or obstructed by the turnings and windings of the sea-coasts, by some thick clouds, or by a multitude of other causes, which may happen to break, reflect, and give such wind a quite different direction.

The variety of these causes, which thus conspire to change the source, direction, and qualities of these winds, is so great, that we can never expect to attain to any certain or useful knowledge of them, by the dint of the most diligent enquiries. It is certain, however, that these winds, how irregular soever in their course, are very advantageous.

When the cattle begin to droop and faint, through a long series of sultry weather; when the verdure of the meadows begins to fade, the sea often sends, at a seasonable juncture, a westerly wind, which brings with it the wished-for succours of refreshment. This

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moist wind, however, the long continuance whereof might prove injurious, not only to the productions, but the inhabitants of the Earth, is often repelled by an east wind, which directing its course from Asia into Europe, and finding no sea in its passage, introduces both fair and dry weather. The wind which blows from the north brings along with it an infinite number of congealed particles of air. It precipitates, scatters, or contracts, all the malignant exhalations of autumn: it contributes in a great measure towards the fertility of our lands, either by bringing a larger quantity of salts along with it than any other winds, or by not dissolving so much of those salts which it meets with in the air of our climate, or by preventing the dissipation of them, rather amassing them together; as the winds that blow directly into the mouth of a river accumulate and swell the water, without making the least addition to it. However, the keen edge of that sharp wind is taken off by the winds that blow from the torrid zone, and which diffuse through the air that genial warmth, which imparts new life and vigour to the whole creation. These continual vicissitudes give a new turn to the dispositions and productions of the Earth; they correct those ill consequences which unavoidably flow from a too tedious inactivity and state of rest; and, in short, purify the air, by keeping it in perpetual motion. Without their friendly assistance, our habitations would be unwholesome, and in a short time become as nauseous as a common-sewer.

The winds then, it is plain, are the servants of mankind, since they are not only commissioned to warm and cool us, as occasion requires, but to keep our houses clean and free from infection; and carry away whatever is offensive, and may pollute the air, without being discerned by the most curious eye.

C H A P.

CHAP. III.

Of the Clouds, Rain, Hail, &c.

CLOUDS and rain are composed of vapours raised from water, or moisture only. These vapours are demonstratively no other than small bubbles, or vesiculæ, detached from the waters by the power of the solar or subterraneous heat, or both; and, being lighter than the atmosphere, are buoyed up thereby, until they become of an equal weight therewith, in some of its regions aloft in the air, or nearer the Earth, in which those vapours are formed into clouds, rains, snow, hail, lightening, dews, mists, and other meteors. But of all these we will proceed to speak more particularly.

The evaporation of the waters, which is so requisite, as well as so constant an effect of the air, at first view seems altogether impossible, and repugnant to reason. As water is a much weightier fluid than the air, how should the former ascend into the latter, or be supported by it?

Nothing can possibly give us a more adequate idea of the evaporation of the waters, and of its various effects, than a kind of pastime which is very common among children. In the first place, they dissolve a small quantity of soap in some water. Then they take a drop of it at the end of a reed or pipe, and blow into it, which is thereby gradually filled with air, and swells into one of those large parti-coloured bubbles or bladders, which strike their fancy, and afford them such an agreeable amusement. The operation is thus performed: he, who forms the bubble, forces into it, through his reed, some of that warm air which he drew from his lungs. The heat, which had before rarefied that air, dilates that likewise in the drop of water: that air being augmented, repelled, and encreased by a fresh blast of some continuance, dissipates those grosser particles of matter which hinder its expansion; that is to say, the water, the oil,

and other materials, of which the soap is composed. Now, since the external air resists on every part the action of that within, it necessarily follows, that the fire and air enclosed within the bubble, instead of advancing in a direct line, have a circular motion, and form a sort of vortex, the extremities whereof is occupied by the water and the oil: these being repelled by the air within, and compressed by the circumambient air, form a little, smooth, hollow globe. Again, as the dilated air, which possesses the space within the bubble, is, together with the water and the oil, a lighter body, or at least as light, as a like bulk of condensed air, whose place is supplied by the bubble, it must therefore be in equilibrio with the contiguous air, and be supported by it. The least breath of wind would be able to make it either rise or fall. This is sufficient to give an adequate idea of the action of the Sun and wind on those waters which are exposed to their respective powers.

The inflammable matter, which the Sun darts down upon the Earth, penetrates with ease through the surface of all bodies that are moist and fluid: it insinuates itself into those vesicles of air, which cause the air to be a fluid substance. By the rarefaction of the air, it swells, and of necessity dilates, that small body of water in which it is enclosed. Those fiery particles, so darted down by the Sun on the surface of the Earth, or the water, are reflected, and reascend, carrying along with them that small portion of moisture, or water, into which they insinuate themselves, and of which they form a kind of vortex that winds about them; and, as the waters contain several particles of those ingredients, which are intermingled with it, the burning matter not only carries away those vortices of water, but several other heterogeneous bodies along with it; namely, the volatile salts, the oils, the sulphur, and divers other corpuscles, which either proceed from the flesh of animals, or flow from the bowels of the Earth, or from mines, into the sea, where they either incorporate with the water, or, for the most part, float on the surface of it, like a froth or scum, that is more or less obvious to the sight. As these particles

particles of fire carry with them an infinite number of such globules of air and water, they, by consequence, take with them likewise a considerable quantity of volatile salts, oils, bitumen, and the tinctures of various metals. The fire and dilated air possessing themselves of the inside of these globules, or bubbles, the water and the other particles which are repelled expand themselves towards the extremities, and form the outside: all those little globules being lighter than the gross or condensed air, in whose room they are substituted, must of necessity ascend, and continue so to rise, till they meet with a more rarefied air, with which they shall be in equilibrio, and where they will stand at least suspended.

The water cannot possibly attain to this degree of lightness, but by the dilatation of the air contained in it; nor is the air thus powerfully expanded but by the fire which has insinuated itself into it; nor would the whole thus ascend in vortices, but by the impression of that fire, all the particles whereof naturally tend to fly upwards, and particularly in spiral lines, through the equal pressure of the circumambient air.

The existence of these bubbles is not altogether imaginable; for we may plainly discern an infinite number of them rising from the surface of boiling water. Those which are imperceptible, form, by their reunion, that steam which rises and evaporates from it.

When we have an adequate idea of the manner in which evaporation is performed, it is easy enough to discover the effects of it. Those bubbles, which are thus formed by the heat, and caused to rise in greater or less quantities, hang, and continue suspended between that body of air beneath them, which is more ponderous, and that above them, which is lighter than themselves. At a distance, this assemblage of exhalations appears a solid body, which we distinguish by the appellation of a cloud. Travellers, however, have found, by frequent experience, that the blackest of those clouds, which they have observed from the foot of mountains gathering over their heads, upon their reaching the summits of them, were nothing

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more than the thick mists, not unlike those which we often find settling upon our level grounds.

The winds, whatever be the cause of them, which put the air in action, concur with the different degrees of its dilatation, to determine the course, the assemblage, the clash, and the separation of the clouds.

When these bubbles, which are distributed all over the atmosphere, meet with an air which is cold and condensed, and has more power to compress, than the particle of fire that is enclosed within has to dilate them, then the particle of air, which lies in the centre of each bubble, contracts itself, the bubble diminishes, and the external part becomes more solid. As the bubbles, therefore, decrease in their bulk, they, by consequence, according to their gravity, be it more or less, either sink by slow degrees, or descend with impetuosity, in the various shapes of *mists, mildews, dews, or gentle rains.*

If in their descent they meet with an air so cold as to congeal them, they are formed, according to their condensation, into flakes of *snow* of various sizes; and, as such snow is always composed of oil, volatile salts, and a particle of fire enclosed in the centre of that little condensed mass, as in a cover, or case, it must consequently follow, that those lands on which it falls must be improved, and rendered fertile by it; and this is a truth confirmed by constant experience. If it be true, that there is any air shut up in those flakes of snow, so as that we may consider each of them as a small concave body, the outside or shell whereof is composed of congealed water, then, when the snow begins to melt, and the imprisoned air, which swelled those bubbles, comes to be dilated, the water so dissolved, being but a part of it, cannot possibly fill so large a space as the snow did, (which is likewise found true by constant experience) and, by consequence, those bubbles, or vesicles, by which we accounted before for evaporation, must be real and not imaginary bodies. Let us now proceed to the other variations which frequently attend them.

If a torrent of air impels, or dashes with violence one large cloud against another, then a considerable
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part of those bubbles, or vesicles before mentioned, burst. The water, whereof they are composed, flow on every side, and falls in larger or lesser drops, according to the action of the winds, which either drive them in a perpendicular or circular direction. Their bulk increases in proportion as they incorporate in their fall; from whence it happens, for the generality, that the rain which descends from those clouds that hover over our heads, and which we sometimes touch, is very small; whereas those drops which fall from more distant clouds, are of a larger circumference. The atmosphere consisting of several regions, or beds of air, expanded one over another, whose dispositions alter according to the various qualities of those winds which act upon it, it frequently happens, that those drops of rain, which are formed by an assemblage of such little vesicles as are burst, meet, as they fall, in some region of the air, which is cold enough to congeal them in their passage: thus modified, they are termed *hail-stones*; the bulk or size whereof is always determined by that of the drops of rain so congealed in their descent.

From those particles of fire, which were pent up in the centre of those vessels before mentioned, and from those other oily, sulphureous, nitrous, and combustible particles, which the water had carried along with it into the upper regions, a train of inflammable matter is formed, which becomes more or less visible, in proportion to the strength and dimensions of it. If the quantity of fiery particles proceeding from the broken vesicles, upon the clash of two clouds, proves very small, forming only a globule of fire, that soon breaks and disperses, shoots out into a stream of light, and immediately disappears, such a phenomena is what most people term a *falling-star*.

If such a stream of light be extended farther, or meets with a stream of other matter, to which it sets fire as it rolls along, it is then called *lightening*.

If such a stream of inflammable matter darts down like a torrent of fire, it is then termed a *thunder-bolt*; the effects whereof are different, according to the

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action of the wind, and the power, or malignity of the ingredients, whereof such flashes are composed.

The air which is rarefied, upon the bursting of those vesicles wherein it was before confined, and that which it meets with imprisoned between the clouds, must, of course, be prodigiously dilated by these inflammable matters; when, therefore, it is pent up by thick clouds, which are impelled by contrary winds, or clash one against another, it can exert its elastic force no other way, than by bursting through them with a terrible explosion, which awful crack is what we call *thunder*.

Though this violent crack, or clap, is but one single act, yet there seems to be a repetition of it, and it lasts for some considerable time; because the sound is reflected from the surfaces of several clouds, and repeated by as many echoes.

As soon as ever these fiery particles burst from the vesicles wherein they were imprisoned, and those other combustible matters which they set on fire, dilate the air, and put it into a violent agitation, it of necessity follows, that the neighbouring clouds must yield to the violent shock, must contract themselves, and be prodigiously compressed. The vesicles, or bubbles whereof they are composed, burst in their turns, and their fiery particles are discharged in all directions, which by consequence create a succession of flashes, and cause the rain to descend with greater violence than it did before. These heavy showers, for the most part, immediately succeed the thunder-clap.

Though several winds arise from under the Earth, where they are formed by a stream of air, which the subterraneous fires dilate, and expand to a violent degree, yet there are other winds which proceed from the clouds, and make a terrible havock in a small spot of ground, falling sometimes directly, as it were, upon it, and in a kind of vortex, without making any further progress: and this effect, it is plain, can be ascribed to nothing but the air, which rushes from the broken vesicles in different directions, the elastic power whereof is exerted most in that part where it meets

meets with the least resistance from the pressure of the clouds. Hence arise those stupendous and fatal effects of the winds, which are most severely felt in times of thunder and storms. The first wind that drives before it the body of the cloud, blows for the generality in a circular direction: there is frequently another which blows at the same time from a quite different corner, which occasions the meeting of the clouds, and their clashing one against another. After the lightening, and the clap of thunder, the sudden and tremendous shock of a third wind is frequently felt, which is that air so discharged from the middle of the cloud, as before mentioned. This last wind in its descent carries with it a suffocating heat. Sometimes it disperses in an intolerable stench of sulphur; from whence the nature of those materials, which were conveyed into the regions of the air along with the vapours, may easily be discovered: and when the impetuous blast of such wind meets in its passage with a bed of inferior clouds, the vesicles whereof, by the expansion of their fire, have been congealed and condensed into hail-stones, it drives them down at once like so many bullets, and the weight of them oftentimes proves more fatal than the thunder-bolt itself.

When different winds rush from the centre of different clouds, and join with those which blew before; the storm encreases: all the winds wing their way to the combat with a whizzing speed, the air whirls round in rappid eddies, the smoak instantly descends, the dust rises, the darkness gathers, the rain pours down in floods, the lightening, hail, and thunder—all contribute towards a general desolation. The flowery meadows, and the countries round about, are all laid waste, and turned to hideous deserts. Can such irregularities as all these, which seem to put all nature into a general consternation, be the handy-works (perhaps you will say) of an all-wise Creator? But do not, fair reader, too rashly call that an irregular proceeding, which is as much the result of fore-sight and design, as that law of motion is, by which it was occasioned: the awful thunder, and the frightful tempest, are as much the works of the Almighty.

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mighty, as the most tempting fruits, or the most fragrant flowers: the most nauseous medicines are the effects of his creating power, as well as the most palatable dainties: he is honoured and obeyed by the most outrageous storms, as well as by the gentlest zephyrs. There is not one of all his creatures, how mean soever, but what proclaims his praise; for all of them daily perform their several functions, in absolute obedience to his Divine will!

The Sun, who invigorates and enlivens all nature, prompts us to the adoration of him, in whom we live, move, and have our being. The light, which embellishes and gives a grace to the whole creation, is a most lively representation of him, who is the source and quintessence of all beauty and perfection. The rivers, the forests, the verdure, and the fruits, un-animously conspire to declare the goodness of their Maker, and his tender concern for the whole race of mankind. The awful voice, however, of his thunder, is intended to rouse those out of their lethargy, who either abuse, or seem insensible of his favours; and, though it does not often destroy them, yet it at least alarms them, and serves them as a lesson of instruction. Every object which we see proclaims God's glory, and is either a display of his divine indulgence, that we may be induced to love him, or a demonstration of his terrors, that we may be compelled to fear him.

Such tempests, however, as we have been here speaking of, are not intended as an admonition only, since they purify the air, which, by a too long stagnation, would prove unwholesome. They destroy, likewise, an infinite number of insects, which, though in some respects useful enough, would become pernicious and destructive to mankind, were they to multiply without restriction. They fill the cisterns and reservoirs of such countries as have no springs, and supply our rivers with more water in one hour, than moderate winter showers of rain in several months.

The same causes which produce the evaporation of the waters, and all those other meteors which roll over our heads, produce likewise other effects, as fatal and shocking,

shocking, under our feet, that is to say, earthquakes and eruptions of volcano's; which we cannot introduce in a more proper place, as it is the very same water, and the same air, that produce the one as well as the other.

Such vapours as are condensed, and distill in rain, serve to cleanse our habitations, and carry along with them the salt-petre that lies on the surface of the Earth, the salts with which the bodies of animals abound, the oil, and all the various impurities which they meet with in their passage. These waters, with all the filth they have contracted, soak into the Earth through an infinite number of channels: sometimes they direct their course over a bed of salt, at others, over layers of sulphur: here they pass through large mines of iron, there through beds of vitriol: they dissolve and carry along with them divers particles of all these several materials. These subterraneous rivers, (the existence whereof we shall hereafter speak of more largely) cast up and lodge on each side of their channels, all these inflammable and active materials, which dry up one another, in proportion as the water sinks and falls away. The least particle of fire, brought thither by the action of the wind, or any other way kindled, whether by means of fermentation, which is no uncommon thing between sulphureous and metallic bodies, or by some small quantity of sulphur, which burns in the subterraneous caverns, inflames the particles of oil that are adjacent to it, and those impart it from one stream of sulphur to another. All these large streams of sulphur take fire, the stony particles are calcined, the mineral particles dissolved, the air, which is conveyed with the water into those subterraneous caverns, is dilated, and with violence repels the salt-petre, which is the hardest and most unalterable of all those inflammable ingredients. The dilatation of the air, and the projection of those salts with which it abounds, are such terrible, such powerful and numerous agents, that they make the surface of the Earth to shake and tremble, wherever they meet with the least resistance: they overthrow whole towns; and whole kingdoms would

would be laid waste, if the Divine Wisdom, who knows perfectly well both the conveniencies and inconveniencies of those formidable powers, did not set bounds to their effects, by opening several *volcano's*, at a proper distance one from another; that is to say, vent-holes, through which the condensed air, with all the other combustible materials that rend the very bowels of the Earth, may have room to discharge their fury. All these inflammable materials being thus dispersed in the open air, lose, by such dilatation, their active powers, which, when united, would be irresistible, and drive before them every thing that opposed their passage. Thus those very *volcano's*, which are considered by most people that live near them as judgments, and the plagues of their country, are assigned, by the indulgence of the Almighty, for their welfare and preservation.

Let us now recapitulate, in as few words as possible, the various effects of the air, we have been treating of: winds, vapours, fogs, clouds, dews, rains, hail, snow, lightening, thunder, earthquakes, subterraneous fires, and tempests: all these surprising phenomena of nature are the effects of the elastic power of the air, which is sometimes condensed, and at others rarefied, according as different causes act upon it. A few feet of air, dilated by fire in a small mine, are of sufficient force to blow up a bastion, and destroy all the battalions that are in it. By the bursting of a body of air impelled upwards, by some subterraneous fires, the famous cities of Nice, Herculane, Antioch, and Palermo, were swallowed up, and buried in the deep abyss. If such a small quantity of air, by the direction of the Almighty, can prove an instrument sufficient to bring about the greatest revolutions both in nature and society, how wonderful must the mechanism and structure of that spring be, which he has imparted to a small body of that tremendous element!

CHAP. IV.

Of the LIGHT.

WE proceed now more particularly to that phenomenon, the light, of which likewise the air is the usual channel. And here the first thing that commands our regard, and is the just object of our amazement, is, that a fluid which is so near us, and acts with such power upon us, as the air, should not be obvious to our sight. It is, doubtless, an effect of the Almighty's goodness and indulgence towards us, that he has concealed the air from us, in order to oblige us with the delightful prospect of all his handy works. Could we have but the least glimpse of the air, we should never have any distinct view of any other objects. As each particle of air has surface sufficient to reflect the light, we should see those various bodies which surround us no otherwise, than as through those rays of the Sun, which strike into a darkened chamber, and are reflected by those particles of dust which float in the air. The Almighty, by making the air invisible, has not only enabled us to take a more distinct survey of the objects that surround us, but has concealed from our eyes those things which would give us disgust at least, if not prove a real misfortune to us, could we possibly discern them. If the air, like other bodies, was an object of sight, the exhalations of the Earth would be much more easily discovered; the least smোক would disfigure the rich landscape of the universe; life itself would be disagreeable and irksome to us; we should discern all those gross humours, which an incessant perspiration drives out from the bodies of animals, all the filth that exhales from our kitchens, streets, and common sewers; and society itself would become a perfect burthen. We should imagine our situation both unsafe and contagious, unless we fled into deserts, to avoid the dangers with which we were threatened, or to remove as far as possible from those annoyances, which would be the
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unavoidable

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unavoidable result of such a fight. However, lest those vapours which cease to give offence, or be injurious, upon their dissipation, should, through their invisibility, suffocate, or prove prejudicial to us, in proportion to that body in which they might insensibly be gathered, the good providence of God has not only vouchsafed to remove all those dreadful apprehensions from us, but has also forewarned us of such approaching dangers by their smell, and delivered us from them by the agitation of the winds.

Though he has been pleased to bestow on those particles of air such a fine and delicate texture, as to render them invisible to human sight, yet he has given them, at the same time, solidity sufficient to constitute a body capable of modifying and refracting those rays of light, when they enter side-ways into it; and this property of theirs is an inexpressible benefit and advantage to mankind in general.

In order to understand the effects of refraction, let us divide the terrestrial globe into three hundred and sixty degrees, or equal parts, the half of which is one hundred and eighty. Let us imagine ourselves seated in the highest degree of that half, so that we could see on one part ninety degrees, or one-fourth part of the heavens, and ninety degrees, or one-fourth part more, on the other: it is evident we shall see the Sun only when it departs from that lower half which is concealed from us, and when it begins to rise in that upper half which lies before us. When he has run through the latter, we shall lose sight of him as soon as he enters into the former; and then his rays will reach us no more, but pass obliquely by our climates, and lose themselves in the atmosphere. We should, the moment he sets beneath our horizon, be totally deprived of light, and involved at once in perfect darkness. This, however, we are sensible is not the case: we still enjoy day-light for a whole hour, and sometimes more, after sun-set: so likewise we enjoy the same duration of twilight before the Sun rises above our horizon. Now the great benefit and advantage which we reap from this augmentation of the day, is wholly owing to the structure of the air.

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The wise Creator of the universe has been pleased to diffuse a body of air all over the face of the Earth, the exact altitude whereof no one knows but himself, though we can be certain that it is several leagues high: Dr. Cheyne is of opinion, it may be forty or forty-five miles high. He has appointed such an exact proportion between the air and the light, that when the latter darts down in a perpendicular line to the Earth, it never deviates from its course; but when a ray enters obliquely, or side-ways, into the atmosphere, instead of passing directly through, and pursuing the same course, it is refracted, and bends a little downwards; insomuch that the greater part of the rays which enter into the atmosphere side-ways, descend by that inflection to the Earth. Hence we reap the benefit of that light, which had been totally lost, had there been no air to inflect it to us. Thus, when the Sun approaches our horizon, several of his rays, which pass side-ways, and are invisible to us, meeting with that body of air which surrounds us, are bent down or refracted to us, and seen by us; insomuch that we perceive day-light some time before the Sun, which is the fountain of light, makes his appearance: and we enjoy, likewise, a part of his light when he is departed from us, and emits none of his rays towards us. The air ceases, however, to refract those rays, and bend them down to us, when the Sun has advanced eighteen degrees below our horizon. Darkness then comes on, and intimates to us, that it is time to rest from our labour; and if the Moon and stars continue to oblige us with their twinkling lights, yet still they shine with such a gentle lustre, as is not able to disturb our rest: thus this law of the refraction of light in the body of the air which surrounds us, is a display of the Divine wisdom and goodness towards all mankind, who thereby gain at least two hours of light in a day. It is, however, an act of still greater indulgence to the inhabitants of the frozen zone, since, were it not for these crepuscles, or twilights, they would be involved, for several months successively, in perpetual darkness.

This

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This auxiliary light, which is thus refracted in the night-time by the atmosphere towards both the poles, meets frequently in its passage thither with a very condensed air, thick clouds, and large bodies of ice or snow, which reflect it in various directions, according to the different situations of their surfaces: from hence, in all probability, proceed those casual streams of light, which the philosophers distinguish by the name of *Auroræ Borealis*, or northern lights, and which the vulgar look upon as portentous, and the forerunners of some very fatal events; though, in reality, they have in all ages made their frequent appearance. These lights expand themselves equally towards both poles; and, if they are reflected towards us rather on the northern than the southern side, the only reason is, because the austral pole is too far distant from us, and that light which it reflected is lost before it can come to us, the reflections, as well as refractions, always keeping within those bounds which Providence has assigned them for our convenience and advantage.

The protraction of the day, however, even after the Sun has run his course from one end of our horizon to the other, is not the only advantage that arises to us from the laws of refraction. Should the day break in upon us all at once, after the dark shades of night, in its meridian glory, our eyes would be dazzled, and in danger of being destroyed by its excessive splendor. A faint light, which insensibly encreases, prepares us for the reception of a greater degree of it without the least inconvenience. The morning, which succeeds the twilight, strengthens the optic nerves, and enables them to sustain the light of the Sun itself. Though he shines at last in his full brightness, his beams are but faint at his first appearance. Thus the Divine goodness, out of a tender regard to our frail natures, has used all the precautions imaginable for our safety and defence.

After this transient view of a small part only of that amazing art and contrivance which is so conspicuous in the structure of the air, and of that wonderful harmony which has been established for our use, between the body of the air and that of the light,
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let us proceed more particularly to the nature of the light itself.

How many enquiries might we make about this single body, the light, to which all other bodies are indebted for their colour, and whatever other beauties they enjoy? and, in the first place, we may reasonably ask, whether light in reality be a body or not? Is it the fire itself, or is it only an accident of fire? Does it proceed from the Sun? Does it diffuse itself every where without intermission? Is it an inexhaustible fountain, incapable of the least diminution or decay? Is it in all places at all times? Is it independent of the Sun? Is it round about us in the night as well as the day? Is it always ready to make its appearance when the fire, or the Sun, shall throw it into a state of motion, and by that means cause it to be reflected from the surfaces of other bodies to our eyes? How is it possible that the Sun should project rays of light to us from his own body (for so says Sir Isaac Newton) in less than seven minutes time, through that immense space, which a cannon-ball, though moving with its utmost velocity, would be several years in the performance? Or, how shall we be able to conceive, that, if we suppose an infinite number of mirrors, placed at some convenient distance from the Earth, such a number of rays shall proceed from all the points of the terrestrial horizon, as shall be sufficient to reflect, in the most distinct manner, the image of the whole horizon from each particular mirror?

To what other miraculous cause shall it be ascribed, that, if we suppose as many spectators as we did mirrors before, each individual spectator shall clearly discern the image reflected from all the mirrors he can see, whilst the same images are so multiplied as to be visible without the least confusion to an infinite number of other spectators? How is it possible, that all these collected rays, which cross one another in so many different directions, and sometimes meet together in one point, should be thus accurately and distinctly discerned? though all these mirrors, indeed, and all these spectators, exist only in imagination, yet could they in reality be ranged in the manner above supposed,

supposed, the air would not be altered or effected in the least by them. The rays, by which these wonders would be produced, proceed every moment from their objects; and, if there were but eyes sufficient to behold them, they would be discerned, without any confusion, in all directions.

The consideration alone of that light which is reflected only from one single point of the horizon, will afford us sufficient matter of wonder and amazement; for, on this single point, no matter which it is, as well as on all other imaginable points, there will most indisputably fall seven rays of different structure, which are capable of exciting in us the sensations of seven several and distinct colours, viz. red, orange-colour, yellow, green, blue, indigo, and violet. This is the order, wherein one single ray of light, which is transmitted to us through a prismatic glass, distributes its various colours on a piece of paper: such single ray, in reality, consists of seven distinct lines, and becomes more conspicuous by its passage through a prism. If now the point on which a ray of light falls is, by the nature of its surface, qualified but to reflect one of those seven rays, it will then be of the same colour with the ray that is reflected from it: if it reflects more than one, it is then of a mixed colour, such as cinnamon, slate, olive-colour, &c. if it reflects none of these rays, or scarce any of them at all, it is then black, or blackish, in proportion as they are more or less imbibed; and, if it reflects all the seven different rays, it will then be white. This little point, therefore, imbibes all the variegated rays, to which it bears no resemblance, and reflects such as are more conformable to the nature of its surface.

Though the structure of these rays, which fall upon every object, and in all places, at one and the same time, is such a surprising phenomenon, yet the reflection of those particular rays, which serve to paint on the optic nerve the resemblance of each distinct object, after the refraction and collection of them by the various humours of our eye, is still a matter of more wonder and amazement: our reason is swallowed up in the reflection on these arcana in nature: their
artful

artful contrivance, and their all-wise Author, are equally incomprehensible to our weak understandings!

Philosophy, therefore, deceives us, when she buoys us up with the vain hopes of ever attaining an adequate idea of the true nature and composition of these elements. However, from the consideration of some of those various effects we have already mentioned, it plainly appears, that every particle of air is a little spring-machine of the most exquisite contrivance. After this, how shall we ever have patience to listen to those philosophers, who, vainly imagining that our weak understandings are capable of accounting for all the hidden mysteries of nature, very seriously inform us, that we ought to look upon the air only, as an immense mass of little particles, which are very irregular, and a kind of raspings only, filed off from the corners of an infinite number of triangular, or hexagonal bodies, by the rubbing of one against another. Though Descartes, who first started this notion, was a very good geometrician, it is true, yet it is possible, that the most skilful in that science may be as whimsical and extravagant in their conjectures as other people; and, doubtless, there is no philosophical delusion more fatal and dangerous, than that of imagining the air, the fire, the light, and the whole system of nature, to be the actual, or even possible effect of motion impressed on matter. This hypothesis, though too much favoured by men of the brightest genius, naturally inclines us to be guilty of the most flagrant ingratitude, by placing the Almighty quite out of our sight, and by making us deviate from the truth, by the maintenance and support of such extravagant notions. Though matter should be modified by motion and friction as much as we would have it, yet these causes could produce nothing but inactive masses of matter, which would have no play, beauty, or proportion, or, by incessant frictions, would, in process of time, be reduced to atoms. The motion impressed on matter is nothing but a blind action, that of itself is unable to produce the least instance of contrivance, order, or freedom: it is altogether incapable of forming an organized body—of giving existence to an
orange

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orange or cabbage: nothing but a hand directed by art and contrivance, could possibly form those little commodious lodgments within the thick rind of an orange, for the reception of a juice which is so refreshing and comfortable to those who reside within sultry climates: nothing but a wise and intelligent being could possibly fold up the lesser leaves of a cabbage in that globular form, and secure them from the influence of the air, and the injuries of the weather, by a thick tegument or covering of the larger leaves, in order to make them more tender, and a more agreeable repast.

If now we can trace the footsteps of art and contrivance in the formation of an orange, if the Almighty has not thought it any derogation to his divine majesty to create a cabbage by a particular act of his will, for our benefit and advantage, must we not be compelled to acknowledge, that the air, the fire, the light, and all those celestial beings which move in such perfect order and harmony round about us, and for our service, were created by so many special acts of the Divine appointment! Certainly, nothing but an immediate exertion of his wisdom and power could possibly give such an elastic force to the air—nothing but Omnipotence itself could multiply the rays of light to infinity, and divide each ray into seven lines, or lesser rays of different colours—nothing but the same Almighty hand could possibly form the elements, assign to each of them its peculiar powers, balance those powers in the most exact proportion, and establish that mutual dependance on one another, which is so absolutely necessary for promoting the harmony and regulation of the whole system.

Is motion capable of uniting the fire, air, and water, which are elements of quite contrary natures, in so artful a manner, and in so nice a proportion, as that one shall be no ways prejudicial to the other? Or can it give wings to the air, or the fire, in order to support the water, and keep it in a perpetual state of action and fluidity? Is motion capable of furnishing a sufficient quantity of rain, and other exhalations in the atmosphere, so as that they shall only water and refresh the Earth, without pouring

pouring down like a torrent, and causing an inundation? Is it qualified to form the hail-stones of just such a circumference as will be sufficient to spoil the fruits of the earth, and to chastise the inhabitants thereof for their sin of ingratitude, and yet hinders them from swelling into large fleaks of ice as big as rocks, which would beat down the trees, and destroy those who possess them? Were motion, however, capable at first of forming the air, and its elastic spring, if it could then produce the fire, and impart to it an excessive force, what other power must we call that which so frequently compresses and condenses the air? Who is it that restrains the fury of fire? Why is it smothered, and locked up in a piece of sulphur? By whom is it confined a prisoner in oil or wood? What superior power is that, which keeps it inactive in our closets or cellars, and makes it fit for our service as occasion offers?

He only, who at first created every particle of matter, whereof the whole system of nature is composed, was capable of giving to each respective part that particular form as would contribute most towards the beauty and service of the whole structure. So far ought we to be from thinking, that mere motion could possibly be the cause of that regular form in which each element appears, that we ought to conclude, from the dictates of common sense, that the motion of all bodies, of what nature or kind soever, and the play or action of the elements, are the natural result of that exquisite form, which the Almighty has been pleased to bestow on all the parts of matter, and of that exact order which he has thought fit to establish throughout the whole. Though motion impressed on a mass of iron, copper, or any other materials, will never produce wheels, springs, or any machine whatever; yet wheels and springs, when well made, and artfully put together, will produce just motions, and a regular machine.

To conclude, as we have acquired an adequate idea of the motions of the air, the fire, and the light; so we can, by dint of study and application, find out the influence which these elements have over us, and by
that

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that discovery can make them promote our interest and advantage. Our researches may extend thus far without presumption; but hitherto we may go, and no farther; for, as to the nature of the air and other elements, he who made them, and he only, knows their structure and their essence.

CHAP. V.

OF GRAVITY.

THAT there is such a thing as gravity, is manifest from its effects here upon Earth, and that the heavenly bodies attract or gravitate to one another, when placed at due distances, is made highly probable by Sir Isaac Newton. This attractive or gravitating power was undoubtedly imprinted on all the matter of the universe by the fiat of the Almighty at the creation. What the cause of it is, the Newtonian philosophy doth not pretend to determine, for want of phenomena, upon which foundation that philosophy is grounded, and not upon chimerical and uncertain hypotheses: but, whatever the cause is, that cause penetrates even to the centres of the Sun and planets, without any diminution of its virtue; and it acts, not according to the superficies of bodies, (as mechanical causes do) but in proportion to the quantity of their solid matter.

This attraction, or gravity, as its force is in a certain proportion, so it makes the descent of bodies to be at a certain rate; and, was it not for the resistance of the medium, all bodies would descend to the Earth at the same rate, the lightest down, as swiftly as the heaviest mineral: as is manifest in the air-pump, in which the lightest feather, dust, &c. and a piece of lead, drop down seemingly in the same time, from the top to the bottom of a tall exhausted receiver.

Of what absolute necessity, and what a noble contrivance this of gravity is, for keeping the several globes of the universe from shattering to pieces, as they evidently must do in a little time, by their swift
rotation

rotation round their own axes! The terraqueous globe, particularly, which circumsolves, at the rate of above one thousand miles an hour, would, by the centrifugal force of that motion, be soon dissipated and scattered into the circumambient space, was it not kept together by this noble contrivance of the Creator, this natural inherent power, namely, the power of attraction or gravity.

As by this power our globe is defended against dissipation, so all its parts are kept in their proper place and order: all material things naturally gravitate thereto, and unite themselves therewith, and so preserve its bulk entire. Even the fleeting waters, the most unruly of all its parts, do by this means keep their constant equipoise in the globe.

Thus have we given a short sketch of the principal use of gravity, without entering into the abstruse parts of it, which would not only have protracted the chapter to a great length, but have perhaps proved tiresome and disagreeable to our fair readers.





B O O K III.

Of Rivers, Mountains, Vallies, &c.



C H A P. I.

Of the Distribution of the Earth and Waters.

THE distribution of the waters and the dry land, though it may seem rude and undesigned to a careless view, and is by some taxed as such, (particularly by that learned and eloquent theorist, Dr. Burnet) yet is admirably well adjusted to the uses and conveniencies of our world.

For, in the first place, the distribution is so well made, the earth and waters so exquisitely adjusted, all the world over, that there is a just equipoise of the whole globe: the northern balances the southern ocean, the Atlantic the Pacific-sea; the American dry land is a counterpoise to the European, Asiatic, and African.

In the next place, the earth and the waters are so admirably well placed in the globe, as to be helpful to one another, to minister to one another's uses. The great oceans, and the lesser seas and lakes, are so admirably well distributed throughout the globe, as to afford sufficient vapours for clouds and rains, to temperate the cold of the northern frozen air, to cool and mitigate the heat of the torrid zone, and to refresh the earth with fertile showers; indeed, in some mea-

sure, to supply the fountains and rivers with fresh water. So abundant is this great blessing, which the most indulgent Creator has afforded us by means of this distribution of the waters we are here speaking of, that there is more than a scanty, bare provision, or mere sufficiency, even a plenty, a surplussage, of this useful element, fresh waters; and they so well ordered, as not to drown the nations of the Earth, nor to stagnate, stink, and poison, or annoy them, but to be gently carried through convenient channels back again to their grand fountain, the sea, and many of them through such large tracts of land, and to such prodigious distances, that it is a great wonder the fountains should be high enough, or the seas low enough, ever to afford so long a conveyance: witness the Danube and the Volga of Europe, the Nile and the Niger of Africa, the Ganges and the Euphrates of Asia, and the Amazons river and Rio de la Plata of America, and many others which might be named, some of which are said to run above five thousand miles, and some no less than six thousand, from their fountains to the sea. Indeed, such prodigious conveyances of the waters make it manifest, that no accidental currents and alterations of the waters themselves (with respect to these large rivers) no art or power of man, nothing less than the *fiat* of the Almighty, could ever have made or found so long and commodious declivities and channels for the passage of the waters.

Let us now turn our attention to smaller rivers. What a delightful scene is a soft murmuring stream! Whether we reflect on the gentle motion of its waters, or on the various benefits and advantages arising from it, or use our best endeavours to trace it to its head, we are charmed with its gliding in such beautiful meanders, the numberless accommodations it affords us, fill our souls with the most grateful acknowledgment; and our curiosity is excited, by the obscurity of its original, to the last degree.

Let us consider it in its gradual progression and increase. It is at first nothing more than a vein of water, issuing from some hill upon a bed of sand or clay.

clay. The little stones that are dispersed all round about are not sufficient to interrupt its current; it turns and winds, and murmurs as it rolls along; at last it clears its way, falls in a torrent down upon the plains, and swells by being united with some other streams; it hollows the ground by the rapidity of its fall, and throws up the earth on each side of it; it insensibly forces its way through every thing that obstructs its passage, and digs a bed or channel for itself; the overflowing of the adjacent ponds, the snow that melts and trickles down the hills, and the additional supplies of various brooks and rills that fall into it, fortify and enrich it: then it assumes a name, and steers its course along the sides of flowery meads, it takes a tour all round the hills, and graces, as it turns and winds, the spacious plains.

It is the general rendezvous of almost all kinds of living creatures; a thousand little party-coloured birds, of various notes, divert themselves upon its sandy banks, skim over its surface, and dip their wings in its refreshing streams. This is their favourite place all day, and, when the approach of night compels them to withdraw, they quit it with reluctance.

Then the wild beasts enjoy it in their turn; but, at the break of day, they leave the plains to man, and the free use of the river to the cattle. The numerous herds forsake their pastures twice a day to pay their usual visits to the streams, in which they quench their thirst, or seek some cool retreat. The river, in short, is as delightful to us, as it is to them: for the most part, we reject the hills and woods, and fix our habitation on its banks.

When it has enriched the fishermen with a profusion of its stores, and refreshed the farmer's thirsty plains, when it has adorned the pompous seats of the nobility with the most delightful prospects, and made the country every way agreeable, it pays a visit to those large towns that are indebted to its friendly streams for all their wealth and commerce.

The principal aim of Divine Providence, in this act of his indulgence, was, no doubt, to furnish both man and beast with one of the most necessary elements
of

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of life, one that will either refresh us when we are faint and thirsty, or serve to dress our daily provisions, and keep our habitations, as well as our bodies, sweet and wholesome.

Should our fair readers here ask, how this river-water, which carries such a large quantity of filth and mire along with it, from the several places through which it passes, can so purge and refine itself, as to answer, in all respects, the purposes before mentioned? they will permit us to tell them, that it discharges itself of all impurities of that nature, by gradually throwing them upon its banks as it passes by them; nor do they rest there long, but are either lost and scattered up and down in the air by the influence or impulse of the wind, or exhaled by the rarefaction of the Sun. If our river-water proves thick and muddy, as it sometimes will, by an intermixture of such particles of another nature, as are capable of producing sediments that prove detrimental and unhealthy, we generally take care, in that case, to let the water stand for some time in proper vessels, where it will soon settle, and become as clear as crystal. In such places where we have not the advantage of river-water, nature has made us some compensation, by furnishing us with springs; or, if we are so unhappy as to be destitute even of them, yet we are very sure, on our digging deep enough in the earth, that we shall meet with well-water.

If we enquire which of these three kinds of water is, for the generality, esteemed the best, we shall soon give the preference to river-water, particularly that of large rivers, as it is, for the most part, lighter and more wholesome than that which rises from either springs or wells. The constituent parts of a fluid, as that of water, may with propriety enough, be compared to those various grains of corn which are thrown into a large mass or heap. If such corn be moved and stirred about upon a floor that is full of dust, or any other impurities whatsoever, the whole mass must be inevitably affected by them; if, on the other hand, it be well shovelled, and thrown from one side to the other, upon a floor that is perfectly neat and clean, it

will purge itself, and the wind will disperse those heterogeneous particles which had before insinuated themselves into it: thus the water that flows from low springs, or is exhausted from wells, having run through, or lain without motion upon beds of slate, chalk, vitriol, sulphur, or iron, washes off some small particles from those various beds, which, if we drink them, may prove prejudicial to our health. River-water, on the contrary, by running for a considerable time in the open air, through the various meanders of its channels, and by that means being kept in perpetual motion, clears and refines itself from all manner of impurities. The rapid motion of its stream in the middle drives every thing before it, throwing up on its shores such bodies as are of a grosser quality, namely, gravel, slime, and filth. As for those bituminous, or oily substances, that are lighter than itself, they float upon its surface, and constitute a sort of scum or froth, which is easily discovered, and soon exhaled by the rarefaction of the Sun. Thus river-water is in all respects as wholesome, and, after it has stood and settled for some time, will be as clear as chrystal, or that which issues from the finest rocks.

Though this element is of a very fluid and fugitive nature, yet the power and consistency of it is such, as that it will bear an inconceivable burthen. Can we behold a loaded barge floating down a river, and not be surpris'd, that such an immense weight should be supported by the water? The specific gravity of wood is less than that of the water, whose place it fills; and not only the lading, but the air that is in the barge, as also the timber whereof the vessel is composed, altogether form a body of less weight than that column of water whose place it supplies: this is the true reason why the barge does not sink. The surpris'ing advantages, therefore, that accrue to us from hence, is grounded on the proportion that there is between the weight of water and the weight of wood, insomuch that not only the vessel, but the freight likewise, is sustained by it. But how vain and trifling would this philosophy prove, should we sit down contented with the bare discovery of this useful proportion, which
these

these two bodies bear to one another, and not reflect on the Divine wisdom and indulgence, who has so ordered the nature of things, as to make them all contribute to our convenience and advantage! though it must be acknowledged, that this water, which we stand in such daily need of, sometimes overflows our plains, and obstructs our passage, yet can we possibly be so blind as not to discover the indulgent intention of Heaven, in furnishing us with wood for the safe transportation of ourselves and our effects over it!

Water-carriage is so expeditious and easy, that in such places where nature has not furnished the inhabitants with this convenience, they will spare no pains or cost whatever to purchase and procure it; they will throw ponds and brooks into one another, they will improve every trifling stream to the best advantage, make basons, reservoirs and canals, lay vallies under water, cut a passage even through mountains, and all to procure the nearest communication they can with some river, for the more commodious conveyance of their respective commodities from one town to another.

The celebrated Peter the Great, late Czar of Muscovy, who had nothing but grand designs in view, secured to himself the conquest of all the countries round about Derbent, and on the shores of the Caspian sea, on the borders of Persia, that he might be accommodated with the silks, cottons, and other rich goods, which are conveyed from those provinces to Aleppo, Smyrna, and even to the Straits of Constantinople, in caravans. By the convenience of those rivers which run into the Caspian-sea, he proposed to import into his own country all the choicest commodities of Asia, particularly their silks, which are manufactured in great abundance at Chirvan. They were to be transported, in the first place, to Astracan, through the mouth of the Volga; from thence they were to pass, by a conjunction of channels, into the river Don, which by another conduit runs into the Occa, and from thence to be brought to the city of Moscow itself by the river Mosca; after that, by several other channels of communication, they were to be conveyed

through the Dwina into the White-sea at Archangel, and at last through the lake of Lagada, which lies at the foot of the Gulph of Finland, to his new town of Petershourg, which, in all probability, by means of its communication with the ocean through the Baltic-sea, and with Asia, by such different conjunctions of rivers as before mentioned, would, in process of time, have been not only the most populous, but the best place for traffic that was ever heard of. The death, however, of that enterprising monarch, deferred the accomplishment of his grand undertaking.

But, to confine ourselves to such conveniencies as have been actually effected, let us see with what success the inhabitants of the United Provinces have raised out of a small tract of land, all covered with marshes, one of the most populous as well as richest states in the whole world.

The great number of their artificial canals, which they support and repair with the utmost diligence and precaution, serve to convey, or to receive those waters, which, without such contrivances, would in a manner cover all their lands. These canals, likewise, are formed into several routes, which are frequently made use of for a communication to several considerable towns, that lie within five or six leagues of one another. An inhabitant of Rotterdam may set out in the morning, breakfast with his friend at Delft, or the Hague, and dine at Leyden; he may either sup the same day at Amsterdam, or, if his business will not permit him to proceed, he may return home again before night, and may read or write as commodiously all the time, as if he was in his closet, and that too without being any ways fatigued, or exposed to those dangers which he might possibly meet with on the road. A farmer's wife, in frosty weather, will take her basket upon her head, vend all her little stores at some distant market, and yet return home again in a few minutes time. She slides, as it were, upon her skates, and scarce any of the family can tell that she has been absent. The frost, however, does not obstruct the carriage of their heaviest burthens: their carts and sledges are substituted

tuted in the room of boats and barges, and are as fully employed on their canals as in their streets.

Let us proceed to take a view of the famous Royal Canal of Languedoc in France, a work of mens hands, which will for ever, at least while this globe shall continue to exist, do honour to the age in which it was accomplished.

A communication between the Mediterranean and the ocean had been long wished for by the French, by means of some artful union of the navigable rivers, and shortening the conveyance of those mercantile commodities, which in times past were transported through the Straits, making the circuit of the coasts of Spain and Portugal. The scheme, however, was always accounted impracticable; because, between the Mediterranean, where the Garonne begins to be navigable, there were nothing more than a few veins of water, and a tract of land above forty leagues in length. However, though the tract was of that immense extent, though the surface of it was unequal, and its elevation towards the middle above the level of the sea, yet Mons. Riquet, with abundance of art and ingenuity, formed the plan of a canal, by means whereof the barges should, by artful ascents and descents, pass from Thoulouse to the Mediterranean, and back again, without the least interruption. Mons. Colbert entertained so good an opinion of this project, and thought it so practicable and beneficial, that he proposed the prosecution and accomplishment of it to Lewis the XIV.

The hill of Naurouse, which is considerably nearer to Thoulouse than it is to Norbonne, was pitched upon as the most proper place from whence to draw two canals, one whereof was to fall into the Garonne, and the other into the Mediterranean. Mons. Riquet made choice of a place upon this hill, which was raised six hundred feet above the level of those two waters, from whence he observes, that the ground lay slanting down almost in one continued descent to them on each side. Upon this spot he attempted to make a large collection of waters, in order to distribute them into

the two canals, one whereof was to descend to Thoulouse, and the other to fall into the Mediterranean.

Though there was but one spring at Naurouse, and that insufficient to answer the end proposed, yet he brought thither, from the adjacent mountains, by virtue of an aqueduct, or conduit of about five leagues in length, a current of water between five and six thousand inches both in breadth and depth; which stream, being distributed in the two canals last mentioned, forms, in every part, a body of water above a million of cubic toises. A toise is a measure consisting of six feet, or a fathom. In order to be guarded against any accidental drought, he caused a large reservoir to be dug near Naurouse, which contained above six hundred thousand cubic toises of water, and was reserved to supply the source of distribution in case of a dry season.

In such places where the land lies upon a descent, the water is pent up in large sluices, between twenty and thirty feet in breadth, enclosed on each side by two high walls that run parallel one to the other, and by a pair of substantial gates. As the water falls down from the upper sluices into the lower, it forms a grand cascade, and strikes the eye of the spectator with wonder and delight. We will suppose a vessel in its passage from Narbonne, after it had sailed through the canal that runs along the plain, arrived at the foot of one of these sluices; the gates are instantly flung open, the water, so hemmed in, as aforesaid, rushes forth with an impetuous force, and, blending with that in the canal, forms one common level. Upon this, the bark sails into the sluice, and the gates are shut up again. The water, which descends from the upper sluice, rises, by slow degrees, several toises; the vessel accordingly rises with it, till it comes on a level with the water contained in the second sluice; by means whereof a bark that is coming from Narbonne may pass without any obstruction out of the first sluice into the second; or one coming from Thoulouse may be introduced out of the second into the first.

The

The gates of the second sluice being shut, the vessel in the same manner mounts into the third; and thus it ascends from sluice to sluice, till it comes to the source of distribution, and then, by the same sort of conveyance, sails down to Thoulouse.

Upon the whole, no work of antiquity, that of the Roman high-ways excepted, can stand in competition with it. This channel, from the place where it empties itself into the port of Cette to Thoulouse, is at least seventy leagues long. Moreover, they were frequently reduced to the necessity of turning and winding it, to preserve the level, to fortify it with piles in those places where the earth gave way, to convey it over bridges and stone arches in the vallies, to lay some mountains level with the ground, and cut a passage through others, and arch them over for the reception of its waters. Above two millions of cubic toises of earth, and more than five thousand of solid rocks, have been hollowed for the preparation of its bed, one hundred and four sluices have been erected for the ascent and descent of vessels, sixteen prodigious mounds have been raised to divert such waters as might any ways obstruct their passage, and four and twenty spacious drains to empty the canal, upon any apprehensions of its being too much embarrassed or overcharged with mire and sands. Upon a moderate computation we are informed, that there are above forty thousand cubic toises of stone-work in these erections, together with a projection into the sea of two hundred toises, and a pier of five hundred, which at present secures the port of Cette, and renders it a very safe and commodious harbour. Though the execution of all this work may, in all probability, appear to be attended with an immense charge, yet it is nothing at all in comparison to the vast advantages which are daily received from it.

Let us not, however, be too partial, or reflect with too much admiration and delight, on the works of mens hands, since they can only employ to advantage those instruments and powers which the Almighty has bestowed upon them. We are lavish of our applause, and stand astonished, as it were, at the sight of a canal only,

only, wherein there is discovered, it is true, the incontestible marks of industry and grandeur; but at the same time we are highly blameworthy, if we are inattentive to, and regardless of, those immense and numberless canals, which the hand of God has extended from one end of the Earth to the other.

But, to proceed, our dwellings become unhealthful, when either standing waters create excessive damps, or when a scarcity of water causes too great a drought: every rivulet refreshes the air of all the parts adjacent by a diffusion of its gentle dews, and frees the earth of all impurities. The most spacious moats that surround our seats, ponds, and lakes themselves, which are frequently formed in the bottom of vallies, are no ways dangerous or unhealthful, provided some living stream does but cross them, or supply them with its waters; nor does such stream act only on the body of that water through which it passes, but on the air likewise, and, by its impulse on both, prevents the ill consequence that might attend the too long continuance of it in one situation. The three rivers that descend to mount Gotard, and run into lakes of sixteen or eighteen leagues long, and four or five broad, by these means hinder the settlement of those damps and fogs which exhale from them, and would otherwise be infectious, and make those who live on the borders of them desert their habitations.

Thus the Tesin, which crosses the lake Major, the Rhine, which keeps the lake of Constance in perpetual motion, and the Roan, which, with rapid force, runs through the lake of Geneva, are the sole cause that purifies the air in all the adjacent parts, and is that alone which secures to the inhabitants round about those valuable blessings which they enjoy.

The fertility of lands likewise is owing, for the most part, to the vicinity of rivers. How surprising is the difference between one country that is plentifully watered, and another to which nature has denied that invaluable blessing! The latter is all dry and desolate, no people will reside in it, or think it worth the pains of cultivation. The traveller that is obliged to wander through it, finding no verdure, or
delightful

delightful objects to amuse him, and hearing nothing but the disagreeable chirpings of a few disconsolate grass-hoppers, instead of the melodious notes of birds, is impatient till he comes to the end of such uncomfortable deserts. At last he arrives at the foot of a hill, whose summit entertains his eyes with the most agreeable prospect. Here he beholds with wonder and delight the vale below; the shady woods, corn-fields, and verdant meads, the villa's round about, and distant villages, are all new and delightful objects. He fancies himself at once transported from the Arabian deserts into the land of promise. Now, that winding river, which glides through the vale, is the sole cause of all this happy vicissitude or alteration.

Our fair readers may readily conceive how a river should give fresh life and beauty to the grass of those meadows, and to the roots of those trees, by which it passes; but how it can possibly communicate the same nutriment to that which is a mile and a half, perhaps a league distant from it, they may be at some loss to account for, though constant observation must convince them, that there are vallies, three or four leagues in breadth, that, by means of one river only running through them, shall have the appearance of a terrestrial paradise.

Nothing is more easily accounted for than this. Plants receive their nutriment, not only from their roots, but likewise from their leaves. It often happens, that when the earth is almost dry, and has scarce any moisture left to feed the roots, the dew which falls in the night-time diffuses on the leaves an humidity which they imbibe, and distribute through the whole plant, the weight whereof at such times (said the learned Hale) is considerably encreased. Now, though the air abounds with numberless particles, or little vesicles of water, which are rarefied and exhaled in the day-time by the heat, but descend in the cool of the evening to refresh the thirsty plants, after a tedious perspiration of their juices, yet the river is the principal reservoir that furnishes this necessary humidity; which, exhaling from it in mists, is transported by the wind to descend in refreshing dews, not only on
such

such places as are adjacent to the river, but on such likewise as are some leagues distant from it. Thus all the parts of nature reciprocally aid and assist each other, and declare, in the amazing variety of their operations, the great author of their being, and evidently demonstrate, that he has a tender regard and concern for the welfare of his creatures, in thus furnishing them with every thing for the pleasures and enjoyments of life.

Let us now proceed to enquire into the utility of this element, with respect to its uses to mills and other water machines.

The water answers all the purposes we require of it, not only by means of its fluidity, but by its prodigious force. The latter is so great, that it works the largest machines, and thereby saves us abundance of trouble and expence: and such is the nature of its fluidity, that it is made to run, stop, dilate, contract, spring and rise, to what height soever we think proper.

The force of water consists in the weight and rapidity of it joined together. A cubic foot of fresh water weighs seventy pounds, or something more: sea-water, by means of those saline particles which are intermingled with it, is more heavy; for a cubic foot of salt-water will counter-balance, or be equal to near seventy-three pounds: and this is the reason why a vessel, when arrived in the mouth of a river, draws more water, that is, sinks deeper: because, as it is entered into a lighter fluid, in order to preserve an equilibrium, it must fill a larger space below its surface.

The mobility of waters may be promoted, either by giving it an artificial fall, or by contracting its stream into a narrow compass. Water, in its fall, acquires, like other heavy bodies, different degrees of velocity, in proportion to its descent. We will not here enquire into the exact proportion of its augmented force; it is sufficient for us at present to know, that its velocity is equal to its weight, and that in case the former be increased two or three degrees, the action or impulse of it will be double or triple to what it is at first. If a large flake of ice falls

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falls gently down upon a bridge, it will prove no ways prejudicial to it; but, if it be carried down the stream with rapidity, it will frequently ruin and destroy it. Thus the slowest current will turn a barge-mill; because, as its flyers are very large, a great body of water presses upon them and whirls them round, notwithstanding the action or impulse of it is but very weak and inconsiderable.

A small portion of the same river, when confined within an arch, or introduced at a flood-gate, will accelerate and carry round the flyers of a large mill, though they be never so narrow, in case they do but alternately dip themselves in the water, and receive its rapid force. In a word, a stream that is but one cubic foot in breadth, when it is contracted within a trough, and so contrived as to fall upon a small wheel, divided into several gutters or trays, for the reception of its waters, will carry the mill-stone round, notwithstanding the weight of it is but small, by the force of its acceleration. The weight of one foot of water that falls any considerable height, acts more powerfully than several feet that run in a parallel line: that weight, however, is still encreased by the rapidity which it acquires in its fall. If the wheel be deposited directly under the trough which receives the stream, each gutter or tray in the wheel will feel the impression only of one cubic foot of water, or, in other terms, the weight of seventy pounds: but, on the other hand, if the wheel be deposited so much below the trough, as that the stream in descending upon it acquires a three-fold acceleration, it will be impelled with a triple force. Thus we find, that a current of water of but one cubic foot only, will, by virtue of its velocity, acquire a moving force, which is equal at least to three cubic feet, that is to say, two hundred and ten pounds, which being constantly succeeded by an action or impulse of two hundred and ten pounds on the subsequent trays of the wheel, is more than sufficient to give a moderate motion either to the mill-stone or the mill-hammers.

Hence, we cannot help reflecting with admiration on that prodigious service, which the velocity and impulse

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impulse of rivers is to all those who enjoy them, in grinding their corn, with the utmost expedition, and at a trifling expence, which otherwise must be executed by the unwearied industry and application of a great number of men or horses, both which would lose their strength in a short time, and want to be relieved from such an insupportable fatigue. The same kind of machine is frequently employed in sawing asunder, after the most expeditious manner, large cumbersome pieces of timber; in beating of rags into a kind of paste for the making of paper; in refining iron and copper with a vast hammer, one stroke whereof will perform more work than fifty of the ablest hands; and, to conclude, in winding of silk into a great number of skeins, and putting, at the same time, five or six hundred bobbins in motion, and all under the care and inspection of one single person.

We shall conclude this chapter with a few words on the service water does us by its natural propensity or aptness to motion. The effects of this peculiar quality are as surprising and beneficial as those we have already mentioned. Water only waits the will of man to alter its course, and run in any direction whatsoever. It diffuses itself not only over his gardens, but his habitations too, if he thinks proper, either through stone conduits, or pipes made of potters-earth, wood, iron, or lead. It serves to embellish the most populous cities with beautiful fountains, and full reservoirs or cisterns, either in the most public squares, or in the dwelling-houses of private persons. It ascends into the out-houses of dyers, brewers, shell-workers, and, in short, of all artificers whatsoever. It rises from the bottom of mines, and frees the workmen below from all apprehensions of those dangers to which they would be inevitably exposed, was it not for its ready obedience to the impulse of the pump. It mounts even to the summit of the highest mountains; from whence it descends again in agreeable cascades, in sheets, as it were, of water, in the figure of dew, or in froth and foam; in a word, it assumes all manner of shapes, and is obedient, in all respects, to the direction of man.

CHAP. II.

Of Springs and Fountains.

AS there is no effect more visible, or more beautiful in nature, than the inexhaustible flux of fountains, and the course of rivers, which roll in pomp and majesty along their plenteous beds for whole ages without controul, so there is no effect, the cause whereof nature seems to have concealed from our eyes with greater precaution. In what commodious places are those immense, we had almost said eternal, reservoirs lodged, which, from their secret and inexhaustible stores, supply with ease the capacious beds of rivers, with such a profusion of water, as are more than sufficient to answer all our purposes, and yet are kept under such due restrictions, as not to overflow, but to render the countries fruitful through which they pass.

Though the Almighty has been pleased to cast a veil over many things, yet we are not to imagine, that he has for that reason forbid our enquiries after them; that veil is not always impenetrable: from whence we may infer, that there is implanted in our natures a thirst after knowledge; and, as the handy-works of our great Creator are the just objects of our admiration, though we are perfect strangers to their first principles and most secret causes, so our wonder is still heightened and encreased, in proportion to the discovery which we make of the particular structure, contrivance, and grandeur of them. Thus encouraged, therefore, let us endeavour to pry into the secret cause of this perpetual motion. The better we are acquainted with a phenomenon that is for ever subsisting, the more sensible we are of the bountiful benefactions of our great Creator, which are for ever obvious to our eyes, the stronger will our motives, doubtless, be to pay him the eternal tribute of gratitude.

There are but three opinions, with respect to the origin of springs and fountains, that we can possibly make

make choice of, all the rest being universally allowed unworthy of the least regard, much less the trouble of confutation.

The first is that of M. Descartes, who maintained, that the water of the sea diffused itself through subterraneous channels, in various directions; and, upon its arrival at the foot of mountains, it met with several very capacious caverns, and such a degree of heat, as was capable of making it ascend in vapours, without taking its saline particles along with it, as being too gross and heavy: that the tops of such caverns, obstructing the ascent of those vapours, they there condensed, and formed themselves into little veins, or currents of water, as the head of an alembic resolves into water the steam which adheres to it.

Such as are advocates for the second opinion hold, that the pores of the earth are so large as to permit the finer parts of the water to pass through it; and yet so small at the same time, as to purge and clear itself of all the saline particles that are mingled with it, insomuch that, though it proceeds from the sea, it becomes perfectly fresh, and fit for drinking, before it intermingles either with springs or rivers.

The third system consists in maintaining, that the sea has no communication with the mountains by any passages under the earth, but all above it; that from the surface of rivers, lakes, and from the sea, a vapour incessantly arises, which is carried through the regions of the air by the impulse or action of the wind in the form of a cloud or a mist, and that, in proportion as it meets with a cold air, or its progress is obstructed by mountains, it condenses, and descends in dews, snow, or rain; that such waters, so descending, afterwards find several interstices, or small vacant spaces, through which they insinuate themselves into the bosom of mountains, and other rising grounds, where they lodge in beds either of stone or clay, and form, by issuing therefrom, through the first aperture that favours their progress, a perennial or perpetual fountain, according to the extent and depth of the basin wherein they are collected.

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We are to suppose, according to the hypothesis of Descartes, that the sea-water meets with no obstruction in its passage underneath the earth to the foot of mountains, into which it afterwards ascends in vapours, and there condenses into big drops by the sides of the rocks. This, however, is not, in any respect, conformable to real fact: for, in the first place, to suppose such an uninterrupted intercourse between the sea and the bottoms of mountains, is mere trifling, since no experiment can be produced in justification of such a conjecture: whereas, on the other hand, wheresoever any subterraneous currents of water have been discovered, they have always run, according to the observations of the most curious, from the mountains to the sea, but never from thence to the mountains.

However, allowing that the waters have that uninterrupted passage which they would imagine, and that they direct their course to the feet of mountains without any obstruction, what inference can be drawn from such a concession? It would then be pretended, indeed, that, as they there meet with a sufficient degree of heat to make them ascend in vapours into the caverns of mountains, the cold would condense them there, and cause them to fall in great drops down the sides, as from the head of an alembic; that then, finding an aperture through those sides, they rush out into the open air, and descend upon the plains. This, however, is only ordering matters conformable to their own inclinations, and not as they are in fact. For, supposing we should grant, that the waters have an uninterrupted course from the sea, through subterraneous caverns of two or three hundred leagues in length, to the bottoms of the most lofty mountains—where, pray, are the furnaces planted, that are duly prepared, and constantly supplied with a sufficient degree of heat to exhale such waters, and make them ascend in vapours? Supposing, again, that we should still further allow, that there is a sufficient degree of heat to answer the purpose before mentioned, yet where are those caverns to be met with of six or seven hundred paces in height, in order to condense such rarefied waters by the coldness of their vaulted roofs?

Though,

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Though several curious persons have, by digging, opened a passage wide enough in the bosom of the earth and mountains to make the discovery, yet no one ever met with such caverns as were large enough to give such exhalations an uninterrupted ascent to the height of those springs, from whence the rivers take their rise. All these wonderful alembics, therefore, are no better than idle and romantic notions.

We will add two other proofs, which are incontestable facts, and which will evidently demonstrate the absurdity of those alembics, which M. Descartes is so extremely fond of. We shall take one of them from what has passed on the external surface of the earth, and the other from what has been observed within the bowels of it.

When no rains have fallen for a considerable time, whether in summer or winter, most springs, we find, will fail, several rivers will be almost exhausted, and those that are the largest will scarce have a sufficient quantity of water to cover their respective beds: now what have the vapours, which are exhaled from the subterraneous waters, to do with the weather, either wet or dry, since their operation does not depend in the least upon it? The water is in the alembic, the head is deposited upon it, and the furnace is heated as usual. Why then does not the distillation go forwards? Was this the cause of springs, as the cause is for ever subsisting, the effect would unavoidably be the same; no external drought, we know by experience, could have the least influence over it.

Let us now reflect a little on what passes within the bosom of the earth: and here we find nothing to countenance such pretended operations, arising from the bottoms of mountains to their tops, in order to form an assemblage of waters for supplying those springs which gush out of their sides. There are numberless grottos and caves, both small and great, that have been visited by thousands; some whereof have proved perfectly dry, and consequently have had no communication with any waters from the sea: others have been found crusted over, in process of time, with a congealed, chrySTALLIZED, fluid; some have

have had little veins of water passing through them, and others have distilled from their vaults some drops of water, which have sunk to the bottom. Now these little fluid vesicles, which perspire through the pores of the caverns, and there turn to stone or chrysal, proceed entirely, according to the general opinion of the best judges, from rain-water, which, penetrating through the interstices, or vacant places of the earth and caverns, carries a parcel of saline or fine sandy particles along with it, which unite, and form themselves into various shapes. The sea, it is plain, has no part or share in this transformation. As to those veins, or little streams of water, which glide through some caverns, they are produced, beyond all dispute, by the rains which soak through the earth, since these veins are either diminished, or absolutely dried up in proportion as the droughts encrease. To conclude, those drops of water, which distill through the sides of some particular caves, can never be imputed to the sea-water, since no such thing is to be found at the bottom of them; since it is plain that their vaulted roofs receive all their humidity from the rain that descends upon them; and, in short, since they become perfectly dry when there has been no rain for any considerable time. That this is matter of fact, is evident from what may be seen in numberless caverns in England, where the waters never trickle down in a dry season.

Should it be thought possible, that the water is brought to the fountains directly from the sea, having lodged its saline particles on the sides of those subterraneous canals through which it had passed, refining and purging itself of all heterogeneous impurities, by a kind of filtration through those rocks and sands which it meets with in its current—we cannot conceive, in the first place, where all those salts must be conveyed, which such a multitude of springs and rivers must have lodged in the bosom of the earth. The sea, according to this system, has been about six thousand years in dispensing its waters and salts to the springs of rivers, and these last have sent nothing to it but fresh water in return. If so, it must consequently

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quently have happened, by little and little, that the sea must either have discharged itself of all its salts, or the earth must have such a profusion of them, as that these salts would have stopped up those subterraneous conduits through which the waters should pass, in order to feed the springs.

It is evident, that, if the sea-water had thus discharged its salts beneath the earth, the ocean, by its passage to and fro, would long since have lost its saline quality, and that the salts would have obstructed the passage of its waters. Let us try, however, if we can give this system some air of probability, by maintaining, that this secretion of the salt from the water is not performed within the bowels of the earth, but in the sands that cover the bottom of the sea.

As these springs are frequently dried up, when there has been no rain for a long time, it is probable they have their rise from a collection or body of rain-water in the bowels of the earth, and not from the sea, which, though the season should prove never so dry, might be always in a condition to supply them: and this observation may be still strengthened by another. If the fresh-waters, which are frequently discovered in the most inconsiderable islands, and those likewise near the sea, proceeded from it by filtration, there would be no manner of difficulty in secreting the salt from the sea-water, and in removing its brackish quality, which would prove a very advantageous article in our navigation. But we are well satisfied, by numberless experiments, that the filtration of it through a hundred different vessels, and as many sorts of sand, would prove vain and ineffectual: the utmost we can do is to diminish its saltiness in some degree; for, notwithstanding all the most artful preparations that can possibly be devised, it would retain its saline and bituminous flavour, which not only renders the water itself, but every thing that is dressed in it, odious and offensive. It inflames the very bowels of those who make use of it, and diffuses in their urine the blood of those little vessels which were lacerated with their sharp-pointed salts. It is true, a method was said to have been discovered, a few years since,

since, in England for purifying sea-water; but, as we do not now find it used by our seamen, we may justly conclude, it was never brought to perfection.

That there are wells of salt water, is a matter beyond all dispute; but we must not from hence conclude that they are supplied from the sea. M. l'Abbe de la Grive, a very able mathematician, gives us a very curious account of what he had observed in the mines of Willisca in Poland, from whence, as he informs us, large quantities of salt have been extracted. "In the year 1522, (says the above author) some salt-mines were discovered near Cracow, which are at this day one of the most valuable branches of the revenues belonging to the king of Poland. They lie under the little town of Willisca, which, exclusive of the church, consists entirely of subterraneous huts, or little houses. There are four apertures or descents that lead down into the mines, whereof the two largest are in the town, through which the workmen draw up the large lumps or masses of salt, and then lay them in the highway or streets, in order that all passengers, as well as horses, may trample upon, and break them to pieces under their feet, before they are carried to the mills to be reduced to powder. The two other mouths, or openings, are principally appropriated to the conveyance of such wood, or other materials, as the workmen have occasion for in those subterraneous caverns. Those inlets, or apertures, are four or five feet square, and lined with strong planks quite down to the bottom. Just at the opening of the pit stands a large wheel, which, being worked by a horse, and having a cable fastened to it about the thickness of a man's arm, either draws up or lets down whatever is thought convenient. Though thirty or forty persons may go down together, yet their manner of descent is something particular: he that goes foremost fastens to the before-mentioned cable a substantial rope, which he winds about him: as soon as he is firmly seated, he takes a fellow-labourer in his lap: these two are let down together about three or four feet only, to make room for a third, who, when he has fastened himself with a cord in the same manner as the first to the

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the cable, takes another labourer upon his lap, and then they are let down about four or five feet, that two others may succeed them. In short, when the whole number that intends to go down have thus taken their respective seats, the horse walks round and round without intermission, and unwinds the cable, till they are all safely landed in their turns upon the first bottom, which is an hundred fathoms at least below the opening of the pit. There they unite their ropes, and, by the assistance of their lamps, proceed side-ways through several turnings and windings which gradually descend, till they arrive at the margin of another pit, which is as deep as the former. However, they go down to the bottom of this by a sufficient number of ladders, placed one above another, so that, before they can come to the salt-pits, they are obliged to descend above two hundred fathoms. The miners, when they are down, go to work, and dig on all sides without distinction, taking particular care, however, as they proceed, to maintain and uphold the top of the cavity, or hole which they make, with large pieces of timber, and other substantial props. There is one thing still very remarkable in these mines, and that is, a vein or stream of fresh-water, which never dries up but when the droughts are very severe, runs quite across them, and serves to refresh, as well as quench the thirst of the labourers when they are disposed to drink, who are sometimes above a thousand in number, exclusive of their horses, which are employed in carrying the salt to the foot of the pits: these poor creature are doomed to live perpetual strangers to the enjoyment of day-light. The air of these subterraneous caverns is so sharp, that it makes them grow blind in a very little time. The miners themselves, indeed, ascend at proper seasons, not only for the benefit of a more salutary air, but for the exercise of their occasional devotions."

It is certain, that the sea does not supply these mines with the least quantity of water, or the least grain of salt. There are veins, or beds of salt, which have subsisted in these, and divers other places, ever since the world has been created, or at least ever since
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the flood: nay, so far are these mines from being supplied with any salt-waters proceeding from the seas, that it is plainly to be perceived, on the contrary, from the account given by the above author, a vein or rill only of fresh water runs across them, which must proceed indisputably from the rains, since it either diminishes or perfectly dries up, according to the severity of the draughts. Besides, it loses itself under ground, after it has so traversed the mines, and falls into the sea below the surface of its waters. It is so certain, that those holes, which have been once dug and supported, are never replenished, that there is a free communication or passage through the one into the other, and the oldest mines are forced, at some particular times, to be strengthened and uphold by fresh props, or large pieces of timber, for fear of future misfortunes. This very article has given some travellers, who are fond of talking in the marvellous way, an opportunity of asserting, that there was a regular town in Hungary, consisting of several streets, which lay above two hundred fathoms deep in the earth, the inhabitants whereof lived like moles, and never saw the cheerful light of the day.

We shall conclude this chapter with these two facts. The first is, that the vapours which ascend from the sea, are much more than sufficient to supply with water, not only the surface of the earth, but the beds of the most spacious rivers. The second, that the mountains, which by their structure arrest, if we may be allowed the expression, both the vapours and rain, collect them in their bosoms, and discharge them again in perpetual or intermitting streams.

However, in order to explain more particularly the origin of fountains, we must proceed to treat of mountains, which shall be the subject of the next chapter.

C H A P. III.

Of Mountains and Vallies.

THOUGH there are some who think mountains to be a deformity to the Earth, yet, if well considered, they will be found as much to conduce to the beauty and convenience of the universe, as any of the other parts. Nature, says Pliny, purposely formed them for many excellent uses; partly to tame the violence of great rivers, to strengthen certain joints within the bowels of the earth, to break the force of the sea's inundation, and for the safety of the Earth's inhabitants, whether men or beasts.

We appeal to our fair readers, whether the great variety of hills and dales be not more pleasing than the largest continued planes. Let those who make it their business to visit the globe, to divert their sight with the various prospects of the Earth, let these judge, whether the far-distant parts of the world would be so well worth visiting, if the Earth was every where of an even, level, globular surface; or one large plane of many thousand miles; and whether, as it now is, it be not far more pleasing to the eye, to view from the tops of mountains the subjacent vales and streams, and the far-distant hills; and again from the vales to behold the surrounding mountains. The elegant strains and lofty flights, both of the ancient and modern poets on these occasions, are testimonies of the sense of mankind on this configuration of the Earth.

But, be the case as it will as to beauty, which is the least valuable consideration, we shall find, as to convenience, this configuration of the Earth is far more commodious on several accounts.

How necessary this variety is to the preservation or restoration of health, a little reflection will soon convince us. Some constitutions are indeed of so happy a strength, and so confirmed an health, as to be indifferent to almost any place or temperature of air; but then others are so weakly and feeble, as not to be able

to bear one, but can live comfortably in another place. With some the finer and more subtle air of the hills best agrees, who are languishing and dying in the feculent and grosser air of great towns, or even the warmer and vaporous air of the vallies and waters; but, on the other hand, others languish on the hills, and grow healthful and strong in the warmer air of the vallies.

Thus this opportunity of shifting our abode, from the warmer and more vaporous air of the vallies, to the colder and more subtle air of the hills, or from the hills to the vales, is an admirable easement, refreshment, and great benefit to the valetudinarian, feeble part of mankind, affording those an easy and comfortable life, who would otherwise live miserably languish, and pine away.

To this salutary conformation of the Earth, we may add another great convenience of the hills, and that is, in affording commodious places for habitation, "serving (as Mr. Ray observes) as screens to keep off the cold and nipping blasts of the northerly and easterly winds, and reflecting the benign and cherishing sun-beams, and so rendering our habitations more comfortable and agreeable in winter; and promoting the growth of herbs and fruit-trees, and the maturation of the fruits in summer."

Another benefit of the hills, is, that they serve for the production of great varieties of herbs and trees; and, as there was not a better judge of those matters, so we cannot give a better account of this contrivance, than in the words of the last cited eminent and learned author. His observation is, "that the mountains especially abound with different species of vegetables, because of the great diversity of soils that are found there, every vertex, or eminence almost, affording new kinds. Now these plants (says this author) serve partly for the food and sustenance of such animals as are proper to the mountains, partly for medicinal uses; the chief physic, herbs and roots, and the best in their kinds, growing there, it being remarkable, that the greatest and most luxurious species in most genera of plants are natives of the mountains."

We shall at present pass over the numberless other benefits accruing from hills and mountains, and proceed to consider them, with respect as to the origin of springs and fountains.

Let us, in the first place, make a comparison between that quantity of water which is exhaled in vapours from the sea, and, when condensed, descends in vapours upon the earth, and that which glides over the beds or channels of our rivers. In the first place we shall endeavour to prove, that the quantity of water which proceeds from such vapours as before mentioned, is considerably greater than that which is daily empai'd into the sea through the mouths of any rivers. As soon as this point is discussed, we will proceed to examine into the manner wherein such a profusion of water is collected in the storehouses of the mountains.

There are some very curious naturalists, as remarkable for their patience as their judgment, who have thought it worth their while to make an exact calculation of the inches of water that might possibly fall on the earth within the space of a whole year. By the reception of such rain, as from time to time descended from the clouds in a proper vessel deposited for that purpose, at some distance from any erection, or eminence whatever, they took notice, for several years successively, of the exact height of the water in such vessel after every shower. Then, by the addition of the several heights together, they found the sum total, not only at London, but at Paris, Lisle, Zurich, and Amsterdam, amounted to sometimes nineteen, and sometimes again to one and twenty inches, little more or less, except in some very dry seasons: so that, upon a modest computation, we may fix the standard height of all the rain-water, that descends upon the earth in the space of one year, at twenty inches, or thereabouts.

Upon a nice calculation (the particulars of which we will not here trouble our fair readers with) made by Mons. Mariotte, it appears, that the whole quantity of rain-waters, which descend upon all the lands that lie near the Seine and about Paris, computing the height

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height of them at no more than fifteen inches, is six times greater than the sum total of the waters that pass out of the river Seine into the sea. The rain-water must then, according to such computation, be more than sufficient to supply the rivers.

If such rains diffuse upon the surface of the earth, a much greater quantity of water than it empties into the rivers, what, (you will perhaps ask) becomes of the surplus?

The remainder, which is very considerable, serves not only to quench the thirst of all living creatures, but contributes very much towards the nutrition and refreshment of the vegetable part of the creation. The whole earth is covered with a vast variety of plants, which imbibe in the day-time, through their roots, those waters which are diffused under ground, and suck in, during the night, through their leaves, those dews which constantly descend upon them. We may form a judgment of the prodigious expence of waters that is requisite for all vegetables in general, by the quantity that is absorbed or drank up by one single plant. Two fig-leaves, which were put into a phial full of water, by Mons^r de la Hire, sucked in the sixty-fourth part of it in six hours time. According to that observation of his, they would have imbibed a two-and-thirtieth part in twelve hours, a sixteenth in four-and-twenty, an eighth in two days, and the whole in sixteen.

Another objection may be here started: since the vapours diffuse upon the face of the earth a much greater quantity of water, than those rivers discharge into the sea, you will ask what is the reason why its stores are not diminished? If it continues to lend more than it is repaid, it must certainly, in process of time, be totally exhausted.

Though this objection may, at first view, seem plausible enough, yet, when we come to compute, though after an imperfect manner, the quantity of vapours that are exhaled from the sea, we shall find it altogether groundless. In the first place, then, let us suppose, as we may very justly do from a cursory view only of the globe, that the surface of the sea is nearly

as extensive as that of the earth, and let us then consider, whether the inches of water, which arise from the surface of the sea, are more or less in number, than the eighteen or twenty inches of rain, which annually cover the earth.

If we let a pail of water in the open air, when the weather is extremely hot, and more particularly if there be a brisk gale of wind, an inch of that water will be exhaled within the compass of four-and-twenty hours; at other times, not above half an inch of it will ascend into vapours. Sometimes, again, when the weather is cold, no more than a line, that is to say, the twelfth part of an inch, will be lost; or, in short, the evaporation will scarcely be discerned. Our millars, whose interest it is to keep the water up to a certain pitch, take particular care to confine it, collect it into a body, and hinder it from flowing out with greater acceleration than it runs in. It is a general observation among them, that such a small mass, or collection of waters thus artfully secured in their dams or sluices, will diminish, for the most part, half an inch, and sometimes, in excessive hot weather, an inch or better. From what has been premised, therefore, we may reasonably conclude, that from all the seas, which are situate between the tropics, there is half an inch of water exhaled every day; however, it is possible, the diminution may not amount to more than a line *per diem*. Upon a medium, therefore, we may with modesty fix the quantity of water exhaled, from one end of the sea to the other, in a day, at a quarter of an inch. Allowing, then, this calculation to be just, in the space of a year, the column of water so exhaled will be three hundred and sixty-five fourths of an inch in thickness. However, to render the computation more easy, we will deduct the five-fourths, and say only, three hundred and sixty, that is, one hundred and fourscore half inches, or ninety whole ones. Now, out of the twenty inches that are taken off for the refreshment of our lands, not above ten of them, according to computation, are carried back into the sea by the mouths of our rivers. The remainder, except the small quantity which is reserved for

for the refreshment of animals and plants, is in part returned to the sea through the subterraneous channels, and in part conveyed away by evaporation, in order to join the general mass of vapours, which we always insist to be eighty inches deep, if not considerably deeper. It is true, indeed, that the rain falls as heavy upon the land, as it does upon the sea; for which reason twenty inches must be deducted from the total amount of vapours: but then there are threescore inches remaining. What, pray, must become of this prodigious body of water, or how will the sea be ever repaid so large a loan? The difficulty, however, would be almost infinitely greater, if, after such an evaporation, which robs it, as it were, of such a large body of water, it was likewise obliged to furnish the rivers and fountains, through the subterraneous passages, with their usual stores of water. In short, it would soon be totally exhausted.

The remainder is reserved to supply the necessities of the torrid zone. In the succedaneous revolutions which the Sun makes from one tropic to another, he would perfectly burn the inhabitants on whom he darts down his rays in a perpendicular line, had not the Almighty, by a peculiar act of his indulgence, thrown a capacious veil over them, in order to screen them from the intolerable heat; insomuch that the very season, in which one would be apprehensive of their unavoidable destruction, becomes their winter, or at least the coolest and most agreeable part of the whole year. According as the Sun makes his advances towards the tropic of Cancer, and visits the northern climes, the boisterous winds of that cold corner, which seem ready, as it were, to rush out at the first signal, or word of command, drive before them that immense body of rarefied vapours, which descending, on their accession to the torrid zone, condense, and dash against the Abyssinian mountains, or any other, which they meet with in India, or elsewhere. There they dissolve in floods of rain for several months successively, without the least intermission. These waters descend with a rapid force from the mountains, and are collected at last in the beds of those capacious rivers that

run across the plains. It is by this means that the Indies, the Ganges, the Niger, and the Nile, are supplied with that profusion of water, which flows and diffuses itself like a sea all over the adjacent fields; though the inhabitants of those countries, whose situation is lower than those watery regions, do not see, perhaps, or feel one drop of rain for whole years together. With what pleasure, as well as surprise, must they behold, even while the dog-star rages, their rivers running over their banks, whole floods of water diffusing themselves all over the thirsty plains, and leaving behind them, as they drain off, a slimy substance that renders their soil both rich and fruitful! moreover, at the time of the Sun's departure from thence, and his approximation to the tropic of Capricorn, there are other winds that blow opportunely from the South to the Equator, which agreeably refresh the natives of Guinea, Monomotapa, Congo, Brazil, Peru, and those likewise who reside in the very heart of America. There they send down their stores of water in mighty torrents, rather than gentle showers, and fill those numberless, capacious magazines, which are to feed, for all the year ensuing, the channels of the Zaire, the Oroonoko, the river of the Amazons, and that too of La Plata. These are the principal rivers, which, by emptying themselves through their capacious mouths into the sea, compensate for the loss which it before sustained by evaporation.

Though it must be acknowledged, that the rain has not always, and in all places, a free and uninterrupted passage into the earth, so as possibly to occasion the formation of wells and springs; however, as it has sometimes, and in many places, that alone is sufficient. Though the manner of its progress is above our comprehension, yet the fact is certain, beyond all dispute. There are some prodigious lofty mountains, such, for instance, as the Cordeliers in Peru, the Pike of Teneriffe, and many more, upon the summit whereof the air is more keen and bleak in the middle of summer, than it is in our climates in the severest frosts: and, if this be matter of fact, then what wonder is it, if those vapours, which are conveyed to the top of them

them should congeal there, and cover them with snow; whilst those who reside at the foot of those high mountains, enjoy a temperate air, or are even incommoded with excessive heats? At the foot of such mountains, whose tops are for ever covered with snow (and of this kind are the Alps and the Pyrenees) we find springs, for the most part, which begin to flow in May, but run no longer than September; the cause whereof may easily be accounted for. As soon as the Sun has advanced so near to one of the tropics, as to be able by his genial rays to warm the tops of the mountains, the snow which covers them dissolves, and insinuates itself through the pores of the earth, and sinks either absolutely down to the bottom of those hills, or at least into their bowels; where its progress being obstructed by beds of clay or stone, it gathers together into a body, and there forms a variety of fountains. On the other hand, as soon as the Sun, by his advancing towards the other tropic, has lost its benign influence, the snow ceases instantly to melt, and the fountains flow no longer. There are several springs, whose waters never run but in the warmest part of the day: it is evident, therefore, that the snow-water gives birth to such fountains, and that it insinuates itself a considerable depth into the earth, notwithstanding the passages through which it winds and turns are not to be discovered.

Another fact, which is as certain and obvious as the former, is this, that our springs and wells are very low, and sometimes totally exhausted, when the season proves very dry, and that the return of rain revives the one, and recruits the other. From whence we must naturally conclude, that those rains find admittance to them through the pores of the earth; and since it cannot be denied, that they contribute not only towards the support of some springs, and the renewal of others, but to the maintainance of the largest and most considerable rivers, it is very easy to conceive, that their rise and origin ought to be ascribed to them.

As therefore it is a fact too apparent to be disputed, that these rain-waters do insinuate themselves into the bowels of the earth, we will proceed, in the next

place, to the manner in which the operation is performed.

In the first place, it is an universal complaint, that the moles, worms, field-mice, crickets and a thousand other vermicelli, or little insects, are very pernicious to the earth in hot seasons, by their grubbing it up, and digging an infinite number of little holes in it of various depths. However, the injury they do that way, is amply recompensed by those numberless inlets, which they open for the rain, at such times that we stand most in need of it. Upon the whole, therefore, it is plain they are rather advantageous than detrimental.

Secondly, those little crevices, or crannies, which gape, as it were, on the surface of the earth, in times of excessive droughts, render the passage of the water to the inferior teguments, or layers, more easy and expeditious.

Thirdly, there are little chasms or chinks, to be met with every where under ground, sundry gutters, some greater and others less, several meanders, or turnings and windings, which, like so many draining-wells, give access or admittance to those waters which lie on the surface of the earth, and assist them in their progress to the inferior parts.

Fourthly, there are some grounds more porous than others, which being overcharged with that profusion of waters which they have imbibed, disgorge themselves again, by an uninterrupted current under ground, into some remote valley: for there is such a harmony and correspondence preserved between all the parts of nature, that even those which seem the most independent, are sometimes the most serviceable to one another.

Lastly, we must form a judgment of the surface of the mountains by those of our plains. The latter, it is true, is sieve-like, or full of little crevices, for the admittance of the waters that give birth to those wells, which, if we will but dig low enough, we may find almost wherever we please. The formation of mountains, however, is quite another thing: their summits are full of inequalities, cavities, basons, or vases, exposed

posed to the open air, subterraneous grottoes, and, if we may be indulged the expression, wide-gaping and disjointed caverns: their pikes, or sharp-pointed tops, which mount into the air, arrest those vapours which fall down upon them in snow, mists, or rain. Their cavities receive and contain the melted snows and rains, which sink down, through ten thousand chinks of different dimensions, to the bottom, by virtue of their specific weight. They insinuate themselves with ease through beds of sand and porous earth, till they are obstructed in their passage by more compact beds of clay or stone, on which they rest. In process of time, however, they force their way through the sand, till they come to the extremity of such stone bed, or other compact layer, where they find means, by reason of their gravity, to rush out into the open air at the side of the mountain. According, therefore, as the mass of sand, through which it penetrates, is either deep or shallow, or the hard bed is hollowed or sunk in the form of a basin, in order to contain a less or greater quantity of water; so the fountain or spring, which derives its birth and rise from it, is either an intermitting or one perpetual stream.

The water which gushes out of these basins does not, for the generality, force its passage in the same manner as liquors will through a filter, when it is fixed at the bottom of a cask: for such liquors press laterally, as well as perpendicularly, on the bottom, their weight being perfectly confined, and pent up on every side. The water, however, which is gathered together in those immense receptacles of sand, which the hand of the Almighty has planted in the bowels of the mountains, makes very little, if any impression, on that inferior, hard bed of earth, which obstructs its passage to the bottom. The pressure of one particle of water upon another, is very light and easy; they scarce constitute a fluid body; they are rather parted and disjointed by the small grains of sand which are intermingled with them: by which means the water, which immediately touches the external opening, disengages itself with ease from the sand through which it drains, without being impelled in any violent manner

manner by that water which lies at a greater distance. The latter finding the inferior place vacant, sinks gently into it by virtue of its own gravity. Each grain of sand is an obstruction, and renders the descent of it more gentle; and thus the whole mass or body of water subsides by slow degrees, and trickles down in a gentle torrent. This mechanism of the mountains is not without some convenience and design; for by this means it prevents a too liberal distribution of that water, which otherwise would soon be exhausted; the neighbouring places would likewise be deprived too soon of their necessary stores, before the return of the rain.

Hence we may plainly perceive, that those things which we look upon as altogether unworthy of the least regard, say sometimes as prejudicial, are frequently, in fact, of the greatest consequence and importance to us; the sea, though the saline particles with which it abounds are so very nauseous, is in reality the first spring which serves to quench our thirst; the wind, though we are very apt to complain of it, brings us our vapours from the sea; the lofty summits of the mountains, though looked upon for the most part as altogether useless, help to settle and condense them; the holes, chasms, and crannies, which render the earth so hideous and deformed, serve as so many conduits to convey the waters into the bowels of the mountains, and their beds or layers of solid matter help to retain them: nothing can entertain us more, than that oeconomy and contrivance which is conspicuous in those heaps of sand, which have been industriously lodged in those magazines, in order to prevent too lavish a discharge of their stores at one time, and to supply us, with frugality, according to our several necessities.

Let us now proceed to describe some remarkable fountains near Zurich, the plan of which has been given to the public by the learned Shenchzer and the Chevalier Vallisneri. Here, in one little spot, there are four small fountains, the structure whereof is somewhat particular: the first whereof descends from the top of a rising ground, the second from the middle, and

and the two last arise from the root or bottom. As it has been said, that no source or spring could issue from the summit of a mountain, it may be proper here to be a little particular on that subject.

It is impossible that any spring should flow from the summit of any mountain, unless there be some fathoms of earth, at least above it, or else some higher mountain that lies contiguous to it: if so, the water that falls down from the higher ground, finding an uninterrupted current into the lower, rises again in the latter to near the same height from whence it descended: as the water in a syphon, or a crane, that has two feet, rises to the same pitch in the second as it does in the first. It is the same here. On the side of the hill, from whence the four springs above mentioned flow, there is another considerably higher. All the layers whereof it is composed, bend in a semi-circular form under the dale that parts the two mountains, and several of them rise again in that which is the least. Those beds which pass from the higher hill to the summit of the lower, carry into it that water which constitutes the upper fountain. A second row of layers, which lie lower than the first, and rise no higher than half way up the second hillock, produces that fountain which springs from the middle; and from the extremity of the other beds, which incline towards the bottom of the hill, without rising again, those two fountains flow which lie at the bottom. Thus it is always the rain, which is gathered together on the higher hills that feeds the four mountains on the lower, and at their respective elevations, according as the beds of one mountain bend under the vale, and rise in an unequal manner in the adjacent mountains. Where these layers end, there the fountains begin.

It is some such arrangement of the internal parts of the earth, like this, that produces, as we presume, those wonderful effects which are peculiar not only to the wells of Modena, but those of Stiria likewise. The workmen begin with digging through divers beds of earth, and when they come to a soil that is very solid and compact, like that of chalk, then they begin their

their masonry, and erect their well at pleasure; without being incommoded with the least drop of water, or without the least apprehension of not finding a sufficient quantity at last. When the well is completed, they bore with a large augur, or other utensil of the like nature, the bed of chalk which is the basis or foundation of their building. The workmen, however, withdraw from the well before such augur is removed. Upon the first extraction, the water flows with rapidity into the well, and in a very short time rises to the margin, nay sometimes overflows the adjacent grounds. This profusion of water must doubtless issue from the vast fluid mass which is gathered together within the Appennine hills, at some distance from Modena. These waters direct their course through long subterraneous channels, and use their utmost endeavours to rise through the first orifices, or apertures, that they meet with, to the pitch of those places from whence they descend.

To the examples already produced, which are self-evident, let us add one more of a mountain that lies at a considerable distance from any other; the texture of whose internal parts have been examined into with all the care and circumspection imaginable, in order to procure an adequate idea of the origin and motion of those waters, which in that place supply not only a pond, but several wells and springs: we mean the mountain on which the city of Laon is erected. This mountain stands by itself in the midst of a spacious plain, which perfectly surrounds it. It is near fifty fathoms high, or, perhaps, a little higher in some places. It extends itself from east to west, about a quarter of a league in length; then, making an elbow from north to south, winds in a semi-circle, and returns to the east, in a line almost parallel to the former. But, by the way, this latter arm is not half so long as the other, and the extremity of it is lower than any other part. The city covers the whole first line, and the monastery of St. Vincent terminates the second. The circumference of the whole mountain, towards the bottom, may be about an hour and a half's walk; but, whether more or less, it is no ways material

terial to our present purpose. The ground on which the city is erected, is considerably large towards the ends, but is much narrower towards the middle. Though all the streets in general are paved, yet there are several large squares on one side the citadel, and under the abbey of St. Martin and St. Vincent, that are covered only with sand and grass. Every side of it lies more or less upon a descent, and is embellished with a variety of vines. And thus much shall suffice for the external part of the mountain; we will now examine a little into the inside of it.

The first bed, or layer, consists of a light sand, intermingled with hard stones in several places. As to the thickness of it, it is very unequal, being twenty feet deep in one part, and twelve or thirteen only in another; not altogether four, perhaps, at a small distance from thence, and in the lowest, that is, towards the middle of the city, it is next to nothing.

The second is a stratum, or tegument of rocks, which extends itself from one mountain to the other. This bed is double, having others of sand and soft stone which divide it. The cellars are built between these two strata of rocks, by digging the sand and soft stone out which lie between them. Towards the east there is sometimes nothing to be met with but one solid rock of twenty-five, or, perhaps, thirty feet in depth. It is necessary to be observed, that this rock is broken down in a thousand places.

The fourth bed, which lies directly under the two teguments of rocks, is a kind of brown stone, but extremely hard, and an inch thick, or thereabouts; but this stratum in some places is defective.

The fifth is a layer of sand, of six or seven feet in depth, at some places, and about eight or nine at others.

The sixth bed is a hard, compact earth, which lies at the bottom of those wells, fountains, and ponds, and is dug up in the garden of the Benedictines of St. Vincent. It is in this last bed that the vales of their fountains are hollowed, in order that the water may gain a passage through the adjacent sands. And if at any time it falls out, that some particular wells are perfectly

perfectly dry, whilst others at some small distance from them are plentifully supplied with water, the true reason is, because this bed of earth does not lie altogether level. It makes divers inflexions, rises in one place, and sinks in another. When the foundation of a well is situate in one of these concave or hollow curves, if there be but a drop of water in the sands, it will drain into the well. If however, on the other hand, the base of a well is situate on one of these convex inflexions of solid and compact earth, when the water in the sand decreases, and sinks lower than the summit of that eminence, the well must then be dry of course in a very short time, and can be supplied with no fresh stores, till a new body of water is gathered together in those sands which lie above the convexity on which the well is built.

The seventh bed is a white sand, intermixed with shells. The workmen have no idea of the layers which lie underneath these last, as they have never any occasion to dig lower than the strata of such compact earth or chalk, as before mentioned.

Having thus given a succinct account of the arrangement, in order, in which those layers lie one beneath another from the summit of the mountain of Laon, to one-third part of its height, or thereabouts, it may be very easily conceived, that these waters must fall from above, and not rise from below, those strata of chalk or clay. As the workmen take all imaginable care not to break through the stratum, or bed of hard clay, but to stop up the least crack or fissure, which they can possibly discover in it, such precaution is an incontestible argument, that we should not search for the rise or origin of the water below such stratum, but above it. The pond that lies in the lowest part of the mountain, and is dug in the before-mentioned garden of the Benedictines, has no other origin, or is fed by any other waters, but those springs which issue from the sides of the mountain, and are of the same height. Not only these waters, but those likewise of the wells, evidently proceed from the rains which insinuate themselves into the upper strata, and are

are detained in the sands that lie on the bed of hard clay.

But how (our fair readers may here perhaps ask) can the waters find so deep a passage into the mountains? since the whole town is paved, must not the rains of necessity run down the sides of it? does not the grass (they will say) which grows in those large squares where there is no pavement, obstruct its passage? and how is it possible, that the water should insinuate itself through that surface of rock, which extends itself from one end of the mountain to the other?

We grant that such pavement may considerably diminish the quantity of water, not only in the wells, but fountains too; and an ingenious author, who wrote about the close of the seventh century, long before the custom of paving was practised, informs us, that there was a copious fountain, and a commodious pond, or watering-place, a little below every gate belonging to the city of Laon. There is but one, however, to be found at present, and that on the side of the fort, or citadel, and two or three small fountains, which produce but a small quantity of water.

As to the grass which grows on those public squares that are not paved, it may, in all probability, prevent the water from penetrating into all places alike; but it will be sure of meeting with a prodigious number of small orifices, or apertures, made by various kinds of living creatures, or else some small crevices, or crannies, that wind and turn under ground, and convey the water into the bed of sand.

As to the rock, we before observed, that it was split and broken in a thousand places; and the waters run down into the cellars that are built underneath it in such a manner, that they are obliged to repair every little fissure and cranny that can be found, with substantial mason-work, and to prop-up and support the very rocks themselves with large stakes, lest they should fall, and the houses built upon them sink into the cellars.

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From this survey, therefore, which we have made both of the external and internal parts of this particular mountain, it is plain to a demonstration, that the rain-water sinks very deep into the earth, and that both fountains and wells not only owe their birth and origin to it, but their principal maintenance and support. Now, if this be matter of fact, even where the passage and operation of the water is obstructed by the narrowness of the surface, the thickness of the pavement, and a floor of rocks, with how much ease may we conceive, that such rain-water can insinuate itself in such places where the earth is light and porous, and where there are immense chains of mountains, abounding with capacious basins to supply those rivers which proceed from them!

Let us continue our survey of the mountains and plains; and, by a few cursory reflections on the various effects that are produced by the vapours descending on them, we shall immediately find so near an affinity between the course of those vapours, and the several states and conditions of fountains, that we doubt not but it will appear evident, beyond all contradiction, that the one are the cause and origin of the other.

When the snow that covers the mountains begins to dissolve (for though it congeals in the winter it melts in the summer) they break out into springs, which will flow no longer than such snow continues to waste away; and the rivers which proceed from them will, by consequence, swell in the summer, and cease their running in the winter, which has been often observed in Lombardy, at the foot of the Alpine hills.

If these mountains are covered with snow in the winter only, there are springs and rivers issuing from them, which abound with water when the frosts break, or in the spring, and are often dried up during the summer season.

In those places where the mountains are only washed with rain, and never covered with snow, as is generally the case with those in France, there, as no heavy rains

rains descend upon them, except it be towards the latter end of the summer, or in autumn, the hills and rivers that proceed from them are highest at those times, and in the winter, and lowest in the spring, and for a month or two afterwards.

Where there are no mountains, the snow, as well as the rain, soaks into the earth, or is lost in the adjacent rivers. These being augmented or swelled by those additional supplies of water, lodge a considerable part of them so deep in those beds of earth, which they meet with in their passage, that they form there wells, and other little springs, which contribute in their turn to feed the particular river to which they respectively belong, and either sink with it, or grow perfectly dry, when it meets with no fresh supplies.

As to those waters which sink into the plains, they supply those wells which are dug by the workmen, some whereof are much deeper than others; and such inequality, with respect to their depths, proceed from the different situation of those strata which are fit for the reception of those waters.

We must not, however, always expect to find fountains at the bottoms of hills, or wells, even in the plains. When the summit of any eminence is covered with stone, chalk, or clay, the expectation of finding a spring there would be vain and fruitless; because the rain will run off from those hard beds, and lose themselves either in the plains, or the adjacent river. When the former consists of various beds of earth which are too porous, or when there are too many orifices, or apertures, in such strata or hard and compact matter, the water finds such an uninterrupted passage through those fissures, and sinks so deep into the bowels of the earth, that there are no hopes of procuring the convenience of a well.

These vast bodies of rain-water, which thus descend to the very bottoms both of the mountains and the plains, form a multiplicity of subterraneous currents, which roll into the sea in an invisible manner beneath its surface.

That there are subterraneous currents at this present time existing, is not only confirmed by a thousand authentic

authentic and incontestible relations, but by such persons likewise as have actually worked in the mines. Since most people, however, imagine, that such currents proceed from the sea, we shall endeavour to convince our fair readers, that they come from that collection of waters which soak through the surface of the earth, and that they roll along imperceptibly, and softly as can possibly be conceived, into the sea.

There are several very able and experienced miners in England, who assure us, that wherever such subterraneous currents are to be met with, there is a considerable quantity of air that attends them; and that where those waters are not to be found, there was no air to answer the end of perspiration, and that their lamps were instantly extinguished: which is an indubitable evidence, that the same openings, or fissures, through which those waters found an uninterrupted passage under the earth, served with equal freedom as proper inlets to the air. These waters, therefore, must of necessity proceed from the surface of the earth, and not from the sea.

The same skilful workmen further assure us, that in several mines they have been agreeably amused with the fragrant odours of trefoil flowers at several fathoms distance from the earth. As to the cause, it is easily accounted for: those waters having first descended on the mountains, and from thence rolled over the adjacent meadows, at a season when the earth is embellished with an infinite variety of flowers, wash off some particles of them as they glide through the fissures of the earth, and fill the circumambient air with the fragrant smell. The course of these waters, therefore, is evidently from the earth to the sea, but not *vice versa*.

To conclude; without having recourse to any more arguments, we are assured, by numberless matters of fact, that the rain-waters which insinuate themselves into the bottom of the earth, glide silently into the sea, a great way below the level of its surface. Several subterraneous rivers have been discovered, which empty themselves into the sea, on the coast of Languedoc, near Frontignan, as also on the coast of Croatia,

Croatia, over-against Venice. And, notwithstanding that water which lies at the bottom of the sea is more brackish, by several degrees, than that which runs near the surface, because the grosser salts always sink down to the bottom (let the agitation of the waters prove never so violent) yet in several places there has been a profusion of fresh waters discovered to ascend from the bottom of the sea. Now from whence could they come there, but from off the plains? Among the various prognostics that forebode the destruction of Puzzolo by fire, which actually came to pass in the year 1538, a certain author, who was an eye-witness of that occurrence, assures us, that the sea, at that time, abandonned the shores, and kept at near two hundred paces distant from it; that an infinite number of fish were taken up, which lay gasping for life on the dry sands, and that several fountains of fresh water were discovered issuing from the ground. Though this last circumstance was very remarkable, yet it plainly proves, that those waters proceeded from some rising ground. A celebrated diver, who was employed to search the bottom of the gulf Charibdis for a cup, which one of the kings of Sicily had thrown into it, assures us, that he met with several considerable springs at the bottom of that gulf, which gushed out of the earth like a little torrent.

Those rivers which have been so often seen, as well as heard, to roll in subterraneous channels, and those fresh waters which silently glide into the sea beneath its surface, enable us to give an unanswerable reason why the rain-waters, which insinuate themselves into the earth, do never overflow or cover the surface of it. Their course is regular; and it is from these currents of water, which, after hasty rains, run with proportionable impetuosity into the sea, that we may likewise be enabled to account, not only for those currents in the sea itself, which assemble together, and cross each other in various directions, but for those mountains, or columns of water, which swell, sometimes in a moment, as it were, out of the sea, even when its waters are smooth and perfectly unroiled, and ascend almost as high into the regions of the air, as those

those plains from whence they descended in torrents after a storm.

From what has been said we may conclude, that there is a constant and uninterrupted circulation of water between the sea and the land. The waters of the sea ascend in vapours, and fall down again in snow and rain, either upon the mountains or the plains. Those which descend on the former, find proper basins, or vases, for their reception, from whence they glide along by slow degrees, and direct their course towards the sea, over the surface of the earth, watering, in their progress, both the vallies and the plains. Such as fall down upon, and insinuate themselves into the latter, return through subterraneous channels to the common rendezvous of the waters.

Our fair readers are now, no doubt satisfied, that the great Author of nature has reservoirs in abundance, so advantageously situated in the regions of the air, that from them he pours down a liberal portion of his watery treasures on their summits, which falling gradually down from one story to another, diffuse their refreshing streams all over the thirsty plains, invigorate the verdant plants, and give new life and beauty to the fertile earth. At the same time it is plainly perceivable, that a real correspondence and intercourse is carried on between those parts of nature, which an uninstructed reader would readily imagine had no manner of relation to one another.

When the all-wise Creator of the universe thought proper to expose the sea to public view, instead of concealing it within the bowels of the earth, and gave permission to the Sun and winds to raise another ocean of vapours into the regions of the air, of equal service and importance to mankind, he raised, at the same time, a vast variety of large protuberances, or swellings in the earth, which notwithstanding at first view they may possibly be looked upon as deformities, and as altogether useless, yet, in fact, they are extremely advantageous, and contribute very much, both in the middle of continents, as well as islands, towards the constant and daily collection of such a body of water as is requisite, in order to form those currents which are,

are, as it were, the very cement and bands of society, and necessary for the nutriment and support, not only of the fish and fowl, but of all other terrestrial animals, and of plants. Notwithstanding there is no apparent affinity between the ocean, which is the boundary of France on the west, and those stupendous rocks of the Cevennes, the Vogue, and the Alps, which are their confines on the east, yet both the one and the other mutually agree to supply them with one of the greatest conveniencies of life. The Alpine hills likewise, which rear their lofty heads between Italy and France, feed not only the Rhine, but the Rhone and the Po; and, notwithstanding most of these mountains are doomed to an eternal sterility, yet it is owing to them, that both those countries are looked upon as the gardens of the world. If the Alpine hills, and those of the Cevennes, were removed, the Tefin, the Adige, and the Po, would soon be dried up, and Lombardy would be a perfect waste; the Rhine and the Loire would be seen no more, and the middle, as well as the northern parts of France, would become a hideous desert. All nature is linked together in one chain, the whole universe is the handy work of one all-wise and omnipotent Being; and the wellfare of mankind was the principal and ultimate end of the exertion of his creating power.

Though we have already given an adequate idea of the various benefits and advantages arising from those springs which distill their waters from the sides of mountains, we shall however proceed to recount a few more. They are the receptacles, or private recesses, of a vast variety of such animals as are of singular service to us. In the first place, they serve to nourish and support, without the least care or concern on our part, the bears, the lynxes, the ermins, the martins, the foxes of divers colours, and several other animals, whose skins are converted into the finest furs. The mountains, likewise, are the constant residence of the rein-deer, which are a species of the stag, and of singular service in cold countries, particularly in Lapland, where they are brought up to be tractable and tame. Their skins, which are prodigious warm,

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and well covered with hair, are worn by the inhabitants as their usual apparel, and their milk and flesh are a considerable part of their subsistence. In short, they are very servicable in dragging all sorts of cumbersome burdens over snows; and, though they travel five-and-twenty, and sometimes thirty leagues in a day, yet they will be contented with a little morsel, by way of refreshment on the road.

Those mountains, which rear their heads in the more sultry climates, are the favourite recesses of our buffaloes, which in some countries are trained up to drag the plough. The flesh of these animals, when killed, is frequently hung up in chimnies, in order to be dried, and disposed of to such captains of ships, who are bound to the most distant ports. The chamois, likewise, which are a species of the wild-goat, and creatures that leap with prodigious activity from one rock to another, live and thrive upon these mountains.

Sportsmen are not the only persons who frequent the mountains in pursuit of game over hill and dale; the botanists frequently visit them in pursuit of those salutary simples, which are either not to be found in any other place, or those that grow there, at least, are more perfect in their kind, and have more specific virtues than any that are planted in the most curious gardens.

To conclude, the most hideous and rugged rocks, the wildest and most barren deserts, have their peculiar uses: they are in nature like the shades in a picture, they add a life and vigour to the other parts, and cause them to strike the eye in the most agreeable manner. We indeed, who live in a glorious, fertile country, where we are daily amused with one continued scene of beauties, seem insensible, as it were, of all their charms: as the landscape is for ever before us, it yields us but a very languid entertainment: the deep impression, which it ought to make on our minds as well as sight, is rendered very weak and imperfect: all our admiration is preserved for foreign curiosities, or such things as are extremely uncommon. It is the novelty, however, rather than the marvellous, which

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we discover in any thing that for the most part engages our attention. Our minds are divided in the midst of such a variety of amusing objects, and we not only grow inattentive, but ungrateful for all the blessings we enjoy. The sight of a number of barren mountains, and sun-burnt heaths, gives us a strong idea of the disconsolate station in which we might possibly have been planted, and of those infinite obligations we lie under to the great Author of our being, for settling our residence in so fertile a country, and in such a delightful situation; to which favours, in reality, we are not any ways entitled.



THE YOUNG LADY'S INTRODUCTION

BOOK IV.

Of the different Sorts of Moulds, Fossils, Minerals, &c.



CHAP. I.

Of the different Soils and Moulds in the Earth.

THE various soils and moulds are an admirable and manifest provision of the all-wise Creator, in making this provision for the various vegetables, and other uses of the creatures; for as some trees, plants and grains, dwindle and die in some soils, they flourish in others; so the all-wise Creator has wisely provided for every kind a proper bed.

If some delight in a warm, some in a cold soil, others in a lax or sandy, or clayish soil, some in moist, others in dry places, still we find provision enough for all these purposes. Every country abounds with its proper trees and plants, and every vegetable flourishes and is gay, somewhere or other about the globe, and abundantly answers the almighty command of the Creator.

To this convenience, which the various soils that coat the earth are of to the vegetables, we may add their great use and benefit to divers animals, to many kinds of quadrupeds, fowls, insects, and reptiles, who make in the earth their places of repose and rest, their retreat in winter, their security from their enemies, and

and their nests wherein to repose their young; some delighting in a lax and pervious mould, admitting them an easy passage; others delighting in a firmer and more solid earth, that will better secure them against injuries from without.

Though there are several sorts of earths or moulds, yet we shall speak here in general of only three sorts, which are distinguished in every country from one another; that is to say,

Sand is composed of small angular, hard compliant particles, which resist the action of water, and are in a manner as transparent as crystal itself.

Clay is, in all probability, composed of such particles as have a cubic figure, are solid, and capable perhaps of leading them into various branches, and by that means of adhering, or clinging close to one another; but, be that as it will, we are very sensible, that they are smooth, rich, oleaginous, in all respects ductile, tenacious, and give water no free admittance into their pores.

Loam is an earth composed of leaves, or hollow tubes, by which means it is rendered spongy, and both the air and the water have a free and uninterrupted passage through it.

The different effects of water on these three earths, point out the fundamental difference that there is between them. If water be poured on a mass of sand, it will fill the vacant spaces between the minute grains of it, without being able to enter into those grains themselves: whether the water penetrates into it, or drains away from it, the heap of sand will still be the same, without the least addition to, or diminution of, its bulk. If water be poured upon a stratum or layer of clay, it may probably find some small access to the surface, through the aid and assistance of some heterogeneous particles of earth, which are intermingled with it, and open some little avenues to it, but it will never be able to insinuate itself any considerable depth into the body of the clay. To conclude, water, when poured upon loam, or spongy earth, soon penetrates into it, makes it swell and dilate, and finds constant ingress and egress without interruption.

As the essential difference between these three kinds of earth is very conspicuous, we may look upon them as so many elements, which, with respect to us, may probably be no less simple and distinct, than the salt, the fire, and the air: whatever their internal structure may be, the all-wise Architect of nature made them, from the beginning of the world, what they now are, and has scattered them all over the face of the earth, in such a manner, as to form (by that harmony and agreement, which is visible between them, and by their intermixture with some heterogeneous matter) that vast variety of bodies and productions, in which mankind are constantly supplied, not only with the necessities but the conveniencies of life.

Sands of all sorts have been disposed throughout the whole earth, both within its surface and without any order, to furnish us with all manner of accommodations, through the diversity of their mass, the difference of their hardness, and the variety of their colour.

They are very commodious, in the first place, as they retain, for a long duration, within the interstices, or vacant spaces of their grains, a provision of water to feed the wells and springs, which otherwise would either penetrate too far into the porous loamy earth, and by that means meet with an obstruction in its passage, or else, by descending on the too compact and contracted pores of the clay, would discharge itself at once, like a torrent, and overflow our habitations, instead of supplying them with a gentle and perpetual stream. In the next place, sands are of singular service, as they prevent the best soils from hardening too much, by a separation of those parts which are too tenacious and compact; and, though they be barren in their own nature, yet, when properly intermixed, they render other soils both light and fertile, and by their rough and irregular angles, not only open a free and uninterrupted passage to the water, but to those nutritious juices, by which the various productions of those fertile soils are maintained and supported.

It is by an effect equally surprising, that this matter, which of itself is so loose, and incapable of cohesion,

hesion, becomes the very cement that unites and binds the bricks, stones, and marble, wherewith our houses are built, so firm and tight together. All these materials, how hard soever in their own nature, would, by slow and imperceptible degrees, start out of their proper places, and fall promiscuously one upon another, if they were not laid even, and by some viscous or slimy matter so cemented together, as to be incapable of giving way. The immobility or steadiness of bridges, conduits, and other erections, whether great or small, is wholly owing to that due and proportionable mixture of earth and sand which we call lime: that mortar which is composed of sand and loam is not near so good, nor half so lasting. The lime, which is a loamy earth converted into a stone, and by fire reduced into a powder, so fills all the vacant spaces of the sand, with which it is intermixed, in so exact a manner, and binds all those particles in one mass or body, so closely together, as that, in process of time, it acquires the hardness of a stone, and renders every thing that adheres to it equally firm and substantial. Brick or tile, however, when pulverized, makes an excellent cement, and is frequently used instead of sand. The reason is plain and obvious: the particles of tiles and bricks, when ground fine, have all the hardness and irregular angles of the sand: besides, they are more porous, and by that means the small particles of lime can enter into them with more ease, can fix themselves, and keep the whole more firm and close together. This compound, being made ductile and pliant first by the water, enables the workman to lay his stone directly upon a level, for wherever the cement is too thick, it readily obeys the pressure of his hand, and when it is once fixed to his satisfaction, it will always continue in the same position. The air dries it, and in time exhausts the water: afterwards it insinuates into it, without any dilatation, a vast variety of salts, which cause it to petrify by slow degrees. The prodigious hardness of the cement in our most ancient buildings, is wholly owing to the influence of the air, and the revolution of several ages. We are apt to imagine, that the Greeks and Romans were pos-

filled of a secret, with respect to this composition of their cement, which to us is entirely lost. We may form a judgment, however, by the hardness of this cement, used in those buildings of our own, which are at present of two or three hundred years standing, that we shall by posterity be thought masters of a secret in architecture, the loss of which, in all probability, will be looked upon by them as a misfortune justly to be lamented.

It is the sand, likewise, that gives that cohesion to potters ware. All vessels of this kind are made of a fat and pliant clay; but that clay, when dried in a sultry sun, or in a furnace, decreases in its substance, according as the moisture evaporates from it. The parts fall down one upon another, and such close contact causes flaws, or fissures in the vessel, that renders it altogether useless. And this inconvenience is no ways to be prevented, but by the use of sand, which, being incorporated with the clay, binds the whole mass so firm and close together, that no water, or any other liquor whatever, can penetrate or find a passage through it.

It is this hardness of the sand that qualifies it for making of canals, and other aqueducts; as also cisterns and reservoirs for the preservation of water. Though clay alone will shrink in the wetting, and chop, by being too much exposed to the sun, yet natural sand, or brick or glass reduced to powder, when duly mixed with clay, will constitute a body that will never be subject to any variation.

Sand is likewise very serviceable, through the property of its hardness, in polishing the roughest and most solid bodies, in making the dullest and most opake perfectly clear and transparent, and, in a word, in fashioning, polishing, and cutting glass. Moreover, as it is of use, through the agreeable variety of its colours in the decoration of our parterres, so, through the property of its dryness, it enables us to walk with pleasure at all times in our gardens, whether we make choice of the alley or the terras, since the water that falls on them drains off immediately, which would not be the case was the earth loamy and porous.

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The earths, or soils, whether of the nature of loam or clay, which are found under ground at various depths, alter their properties to such a degree, not only on account of their intermixture with sulphurs, oils, and mineral substances, but of their different preparations both by fire and water, that we may look upon the whole earth as one spacious laboratory, where that all-wise operator, who alone perfectly understands the principles of nature, takes care to compound them in such a manner, as may best answer the necessities of man, for whose service they were principally created.

In one place we are provided with chalks, okers, and boles of all sorts, for medicinal uses, and of all colours, proper for drawing the outlines or sketches of any design which we propose to accomplish, or for painting such objects as may contribute either towards our profit or delight. In another, we have various kinds of marl, which is so justly admired by our masons for its incomparable chalk, and more particularly by our farmers who look upon it as an inestimable treasure. In several parts of England there are inexhaustible beds, or strata, of bituminous earth to be met with, commonly called sea-coal, which, as it contains within it abundance of sulphur and oil, is more proper than any other for rendering iron ductile and pliant, and obedient to the hammer. We use it, as is well known here in England, and several other places, as common fuel, instead of wood. An ingenious French author observes, that the air of London is so surcharged with the sulphureous spirits of the sea-coal, which is daily burnt in that populous city, that a suit of clothes, after it has been worn there for any considerable time, will preserve a sulphureous smell for whole years together, though they should be sent afterwards by sea to the most distant plantations.

C H A P. II.

Of Fossils.

WERE we to treat of *Fossils* as largely as the subject deserves, we might extend this chapter to the length of a volume; indeed, the same might be said of many of the following: however, as brevity is our principal view, we shall pass over many things, and content ourselves with giving our fair readers an account of the most interesting and entertaining matters.

Mankind, in order to live with decency and pleasure, must be supplied with a vast variety of accommodations. For this purpose the Almighty has supplied them with divers sorts of metals, stones, and an infinite variety of other materials, which are not only of daily service, but were intended by providence as a treasure that should never be exhausted. These are carefully lodged in spacious repositories under our feet, where we may infallibly find them upon all emergencies. These useful materials do not lie buried in the centre of the earth, nor so deep in the bowels of it, as to be inaccessible, but are planted at a convenient distance from its surface, that the soil may produce its proper fruits, in due season, without interruption. By this wise oeconomy and forecast of nature, our habitations are richly furnished both within and without, and the same spot of ground produces for our service a kind of double harvest.

Let us open these storehouses of nature, and examine into a few of their contents.

The oils and juices, both liquid and consistent, which are to be met with in subterraneous caverns, are principally sulphur, bitumen, and naphtha, and probably some others.

The natural sulphur is, for the most part, to be met with in such places as lie contiguous to some volcano's; however, it is sometimes discovered in other places. It is customary to dissolve it in a pan set over a fire,

a fire, whence it is transfused into proper moulds, and brought to us from foreign parts, either in cakes or little sticks. The property, which is ascribed to it, of making water as cold as ice, is, upon repeated experiments, found to be without foundation. Though it is principally used in the bleaching of woollen manufactures, yet it is looked upon as a specific remedy against any epidemical distempers, proceeding from noxious vapours, and is often an ingredient in some medicinal preparations. Sometimes, indeed, the use of it proves of dangerous consequence; and that is, when, by being artfully intermingled with salt-petre, it is converted into that destructive powder with which thousands are sometimes laid breathless upon the plains. It would be, it is true, of peculiar service in the protection of one kingdom from the insults of another, could justice and equity, or true valour, be guarded against its fatal effects.

Bitumen is the nearest in resemblance to sulphur. It is sometimes found under ground in brittle lumps, of an oleaginous and fiery substance. At other times it resembles the pitch which trickles from the pine-trees. However, for the generality, it bubbles up out of the earth, and floats upon the surface of the water, like a black oil, which grows consistent, or hardens in the air. In this form it is met with in divers springs, on the waters of the Dead-sea, or the lake of Asphaltites, which covers the ancient valley of Sodom.

That oil which issues from the bottom of the rocks in divers countries, and is called pitroly, (as well as naphtha, which is an inflammable substance, and remarkable for its burning under water) are only sundry species of bituminous bodies. Both of them are made use of, not only as ingredients in several medicinal preparations, but in black varnishes.

It is very probable, that naphtha was one ingredient in the composition of that famous Grecian wild-fire first made use of in the year 717, so often recorded in history, and which adhered so close to the clothes of those unhappy soldiers on whom it was flung, that it was past the art of man to extinguish it. However,

since the invention of more destructive gunpowder, this, as we are told, was laid aside, and the art of making it was soon quite lost.

Though camphire will burn like bitumen on the water, and probably bears some affinity to it, with respect to its qualities, yet it is no fossil, but a gummy or resinous substance, which distils from some particular trees in China, and in the island of Borneo, at the roots whereof it is frequently found in masses or clusters of different dimensions.

Jet, which is universally admired, not only for its beautiful blackness, but its solidity and readiness to take the finest polish, is nothing more than a kind of black bitumen, which being intermingled with some metallic particles, becomes as hard as any stone. From much the same original is produced yellow amber.

It is difficult to say, whether ambergrease, whose agreeable odour is widely different from bitumen, be produced after the same manner: there is, however, a species of bitumen, called the white petroly of Modena, which has a very agreeable smell. It is the opinion of some learned naturalists, that the water, in its subterraneous currents, carries along with it some odorous oils, which, afterwards floating on its surface, becomes still more fragrant in the air, by exhaling those juices which might possibly have too strong a flavour. Others imagine, that ambergrease partakes very much of the nature of musk and civet; the former is an oil with which the antelope abounds; and it is very probable, that nature has supplied it with this unctuous fluid, to give a more beautiful gloss to the hair of it, and to shelter it from the rain. This animal, which is of the goat kind, and is frequently to be met with in the kingdoms of Boutan and Tonquin, carries this oleaginous matter in a pouch or bag, like the beaver. Civet is, in the like manner, taken from a kind of cat or fox, which from thence is called a civet-cat. Ambergrease, if we may rely on the veracity of some authors, is often extracted likewise from an amphibious animal, that is furnished with a profusion of it, and with which, as they tell us, it oils its hair, as occasion offers.

offers. This, however, is nothing more than mere conjecture: besides, such large masses of ambergrease have been found in one place, that it is perfectly unnatural to have recourse to such a supposition as this. Others, again, assert, that it is full of a much meaner extraction. Its origin, in short, notwithstanding all these conjectures, is precarious and uncertain.

As to the different oils we have mentioned, they are variously dispersed, and intermingled with some extraneous currents, which run into the sea. From thence they are exhaled with the vapours, but distributed in such small portions, as not to have any effect upon the senses, at their first descent. However, they rally their forces in a little time, and, by their union with the salts of the earth, become the principles of those sweet savours, which are so refreshing to us, and which we meet with in plants, flowers, and the flesh of a vast variety of living creatures.

Though *sal gemma*, nitre, salt-petre, vitriol, borax, colcothar, and arsenic, are names of things which may be instrumental in doing of abundance of mischief, yet we doubt not, but we shall soon convince our fair readers, that we are extremely happy in being possessed of them.

Salt, which is one ingredient in the composition of all bodies whatever, and seems by Divine appointment to be the cement of the whole system, is, for the most part, a hard and impliant element, whose minute parts are formed facet-wise, and whose extremities terminate in points. It varies extremely, not only in its kinds, but its effects likewise, either because it is incorporated with some extraneous matters, or, because the several particles whereof it is composed are of a quite different contexture. Both these reasons may probably concur in the production of various sorts of salts.

The small layers of salt which are met with in all bodies upon the separation by fire, are appointed, in all probability, to hold fast, by their points and angles, the parts of other elements. They are like so many small pins, which penetrate on all sides the pores of other bodies, and fix them tight. However, as the
pins

pins and nails, which are made use of to join one body to another, may serve as so many levers to displace them, or wedges to rend them asunder, when they are either too large or too numerous; so salt, in the same manner, may sometimes break and dissolve them instead of holding them fast together. It does not, it is true, in order to produce these effects, act of itself, any more than a nail can act upon, and penetrate into, any bodies, without the stroke of the hammer: but it is driven into the small parts of other elements by the impulse of the air, the spring whereof acts with a greater or less degree of force on those bodies which are near it. It may be acted on likewise by the impulse of other bodies pressing upon it. The water, by insinuating itself not only between the particles of salt, but those of other bodies, dissolves them by slow degrees, puts their little surfaces in motion by its incessant impulse, and makes them float for a little time, till they sink to the bottom, by virtue of their specific gravity, as soon as the fluid is in a state of rest; and though the water, by this property or power, becomes one of the greatest solvents in nature, it is notwithstanding the principal vehicle of those salts, which it conveys into the pores of all bodies, and leaves them there to execute their proper functions.

Nor is it the impulse of the water alone on the small surfaces of the saline particles that puts them into motion, since it must be allowed, that there is within those small corpuscles a quantity of air which is capable of rendering them as light as the liquid in which they float.

Such salts as are carried by the action of the water, or dispersed by the elastic power of the air, enter by one of their points into the small cavities of such bodies as they meet with, or into some other pyramids of salt that obstruct their passage. All such particles of salt adhere to one another, surface to surface, and preserve one regular and stated figure. The smallest particles of our common salt seem all cut into eight angles, and six sides, like one of our dice, and, consequently, this kind of salt principally consists of such masses or clusters as are of a square or cubical form. The fine particles

tibles of alum resemble pyramids exactly. Both nitre and chryſtal conſiſt of ſuch particles as appear to have fix ſurfaces, which, by lying one over another, ſome, as it were, hexagonal columns. Vitriol conſiſts of lozenges. The parts of arſenic are flatter, indeed, but then they are extremely ſharp and pungent. All theſe ſalts, be the manner of their aſſemblage what it will, form themſelves into maſſes of one determinate figure, which never alters.

If all the minute particles of each individual kind of ſalt, in their falling one upon another, on meeting together upon one common baſis, in order to their union, form themſelves into ſuch maſſes as are always of one regular and determinate figure, we muſt infer from thence, that all ſuch ſalts were cut from the beginning by the ſame hand, and formed upon one and the ſame plan. Motion impreſſed upon matter, could never act with ſo much regularity and order. Every particle of ſalt, therefore, muſt have been faſhioned on purpoſe, and with a particular view, in ſuch or ſuch a figure rather than any other, in order to produce ſome particular effect. Thus what we have before obſerved, with reſpect to the ſmalleſt bubble of air, we may apply to the leaſt grain of ſalt, that both the one and the other demonſtrate the infinite wiſdom, determination, and free-agency of their great Creator, as fully as that glorious luminary the Sun itſelf.

We will now proceed to take a tranſient ſurvey of ſome of the various kinds of ſalts which he has faſhioned for our ſervice; and which we ought to look upon as ſo many bleſſings, or acts of his indulgence towards us.

Sal gemma, ſea-ſalt, and well-ſalt, are all three originally the ſame. The water of the deluge, lodged, doubtleſs, under the earth, great quantities of that ſal gemma which is now found there, and is as hard and transparent as chryſtal. The rain-waters, which paſs through theſe ſtrata of ſalt, diſſolve ſome part of them, more or leſs, and carry them through ſubterraneous conduits, into the ſalt wells. All theſe ſalts, though their nature is much the ſame, change their colour and quality by the intermixture of ſome heterogeneous

gencous matter; and the salt of some coasts, for the reason above mentioned, is more valued than that of others.

Next to our common salt, nitre, or salt-petre, is that which is most valued. This is frequently found adhering to the vaulted roofs of subterraneous caverns and cellars, in decayed and antiquated buildings, and more particularly where animals have urined for any time. Most people are of opinion, that nitre is a volatile salt, which is exhaled from caverns, through the pores of the earth, into the regions of the air, where it is dispersed as the sea volatile-salt is, in order that both the one and the other, in conjunction with the fire and water, may become the principles of fecundity and vegetation. Let nitre derive its extraction from what it will, it must be allowed that it fluctuates in the air, which abounds with it: however, it is amassed in large quantities where it is at rest, and particularly where animals have urined. It may be proper, perhaps, to distinguish here between nitre and salt-petre, and to assert, that the former is a volatile salt which floats in the region of the air, either this way or that, according as the wind impels it; whereas the latter is the same nitre, but settled, and blended with other bodies. Our fair readers will soon perceive the use which we propose to make of this observation.

The usual method observed in collecting salt-petre, is either to sweep it together from off the stones and walls of decayed antiquated buildings, or to deposite such sweepings in hot water to melt the salt. The water in which such dissolution is made, is afterwards strained off; and, in proportion as it consumes or evaporates in steam, the saline particles, with which it abounded, are chrySTALLIZED, and afterwards refined by several lotions. This salt is an ingredient in several specific medicines. There are some waters distilled from it, which are of that sharp and pungent quality, that they will dissolve some metals, and reduce them into fluids. The power of this salt, however, is most conspicuous in gunpowder, of which it is one of the principal ingredients. It is this salt-petre, in short, that determines all differences and dissensions between
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princes and their subjects, and proves resistless, even where reason itself cannot prevail.

From the observation of the air's being pent up, and compressed within the particles of the salt-petre, we may form an adequate idea of that amazing force, with which a small quantity of gunpowder, when acted on by fire, impels a massive iron ball. The air and water that are locked up in the salt-petre endeavouring, the moment they are acted upon by the fire, to expand themselves, and finding resistance on every other side, rush out with violence through the mouth of the cannon, and drive with velocity the ball before them.

This is the principal cause of the force of this powder; which is evident from the explosion, or violent crack, with which the air dilates itself, and bursts from its imprisonment in the salt-petre, upon its being thrown into the fire. Common salt, though capable of enclosing only a few particles of air, as it chrystallizes in the water, will crack and bounce likewise when thrown into the fire, but not in that violent and outrageous manner. To the air, which is thus incorporated with the salt-petre, let us add that which is of necessity mingled with it, and with the other ingredients, we mean, the charcoal and the sulphur, at the time of their reduction into powder. To these two several portions of air, let us add, likewise, that which fills up the interstices, or intermediate spaces between the grains. We shall not separate the water from the air, since the salt-petre is equally replete with both. Now the fire, which penetrates with ease into the hardest bodies, is obstructed by the air, the air by the water, and that by the salt. Thus the fire becomes more or less formidable, in proportion to the quantity of it, and the obstruction which it meets with. It impels that matter in which it is enclosed, and therewith the ball. The quantity of fire is greater or less, according to the quantity of sulphur contained in the powder, of which it is a principal ingredient. One single spark is sufficient to release those first particles of fire, which never fails of finding confined within the charcoal and the sulphur. According as those fiery particles burst and procure their discharge, their united force is

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propor-

proportionably augmented. The first prisoners, upon their own enlargement, break open the little lodgements in which their companions are confined, and release them all. Their force are now united. The air, being released from its confinement by so intense an heat, exerts its elastic power, and impels those surfaces of the water, and those impliant, sharp-pointed salts that obstruct its passage: whereupon they launch out in an instant, like millions of arrows from as many bows. As the powder acts with much the same force on the ball, which it drives out of its mouth, as on the hinder part, or breech of it, the quantity of motion in both must be much the same. Since, therefore, the cannon is two or three hundred times heavier than the ball it discharges, if the cannon recoils one pace, the ball must at the same time fly two or three hundred paces, in a quite contrary direction. After the same manner we may account for the ascent of rockets.

But let us proceed to two or three other salts, with which we will conclude this chapter.

Alum is a salt that is met with in large lumps or masses, naturally chrystallized, and intermingled with a little earth, and some other heterogeneous bodies. Feathered alum, however, is found only in small lumps, the largest of which are seldom above two or three inches in circumference. This sort of alum, which is very scarce, is transmitted to us from Egypt, Sardinia, and Milo, an island of the Archipelago.

Roman alum is a salt that is frequently met with in some red and transparent stones. Roch alum is found in white stones, that are sometimes both very bright and large. This salt, as well as salt-petre, is collected from the stone walls of old ruinous buildings. As alum is of a very astringent nature, it contacts and binds whatever fluid it is dissolved in, and is principally for that reason made use of by our dyers. It is the cement, as it were, which blends the colours with the stuffs, and glues the ink and the paper together. If it were not for the alum, the ink would sink thro' the paper; and the air would either totally wear off, or tarnish at least, the colours of the stuffs in a very little time.

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From a chemical analysis it appears, that alum consists of an acid vitriolic salt, and an astringent earth or bole intimately united. It is recommended for swelling of the gums, &c.

Vitriol, or copperas, is likewise a fossil salt, which is met with in lumps or masses, at the bottom of mines, or is gathered, like salt-petre, from mineral fountains, intermingled with earth, sulphureous salts, and metalline particles. There are several sorts of vitriol, or copperas; one sort is blue, and another green, the former of which is principally found in England or Italy; that of a bluish-green colour comes from Germany; and that of sky blue from Cyprus and Hungary.

Borax is another salt, which is frequently met with in the mines, particularly those of Persia. From Persia it is transmitted to the Mogul at Amadabat, and brought from thence by the Europeans. Our goldsmiths make daily use of it, not only in soldering their various metals, but in collecting the little particles of gold, which lie scattered about their work.

Arsenic is a sulphureous mineral salt, taken out of a stone called cobalt; orpiment, which is a species of arsenic; and realgar, which is an orpiment that is calcined, are all malignant poisons; against the fatal effects whereof there is no other specific remedy, but a large quantity of oil, which must be instantly drank, in order to sheath or take off the edge of those pungent salts. These caustics, however, are of singular service, when externally applied by our able physicians. They are likewise ingredients in the composition of such colours as are frequently used both by our dyers and painters.

We shall conclude this chapter with observing, that even in the rankest poisons, we may visibly discover the traces of the very same infinite wisdom, contrivance, and design, as are conspicuous in all the other handy-works of the great Author of nature.

THE YOUNG LADY'S INTRODUCTION

CHAP. III.

Of Quarries, and the different sorts of Stones found therein.

FROM the slight survey of fossils which we have just taken, let us now turn our attention to those immense beds of stone, which lie buried under the earth. Had all the vast masses of stone, which lie under ground, been lodged up and down upon the surface of it, we should have been very much embarrassed, and had but little room left for the erection of our houses: had they proved as hard in the quarry as they grow afterwards, all the art of man could never have been able to dig or cut them; and, had they continued in their original state of softness, when exposed to the open air, our houses would never have been secure. He that cannot discern the hand of the Almighty in all this, and his tender regard, at the same time, for our happiness and welfare, must be wilfully blind, and highly ungrateful. Our amazement and gratitude will be still further heightened, when we take a survey of all the various kinds of stone that are lodged in those spacious repositories under the earth, and maturely to reflect on the wise ends and purposes for which they were ordained. In order to the prosecution of this design, we shall, in the first place, enquire into the various kinds of stones that we have any perfect idea of; in the next, on the manner of their formation in those subterraneous caverns where they are found; and, lastly, on the great benefits and advantages arising from them.

Stones in general are divided into two sorts, viz. precious and common stones. The former are either pellucid or opaque. Their value is greater or less, in proportion to their lustre, colour, smoothness, or weight. As to the medicinal, and other marvellous virtues which have been imputed to them, they are nothing more than the mere effects of fancy, and, in short, a perfect illusion.

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Of all such as are lustrous or pellucid, the diamond is the hardest, and the most beautiful and valuable. The best are those that are void of all colour, for if they are tinged with white, yellow, or black, they are in some degree faulty, and considerably lower in price. It may be readily distinguished from all other gems by its extreme lustre and sparkling, as well as the brightness of its reflections. If a little burnt ivory be laid upon mastic, in such a manner as to render it black, and the diamond laid upon it, it will then every way reflect the most lively colours, which is a property peculiar to this gem, since all others will not bear the like trial. For, when they are laid upon mastic in this manner, they either reflect no colours at all, or, if they do, they appear as if seen through a mist. There have been jewellers, who, attempting to make other stones appear like diamonds, have taken a grain of wheat, and, having pressed the oil out of it with a hot iron, and mixed it with lamp-black or burnt ivory, have then put it under the stone, but so as to leave a little room between it and the black tincture. Hence, the transparency, which is partly owing to the stone, and partly to the air, causes it, in some degree, to resemble a true diamond; indeed so nearly, that even some who are skilful in these matters, have been deceived thereby.

Those gems that are most proper to counterfeit diamonds are the sapphire, the oriental amethysts, the topaz, and the chrysolite, because they are all hard, transparent, and may be deprived of their colour by means of fire: this is most commonly done by quick lime or the filings of steel; for, when the gem is buried in these, and put into a crucible with charcoal, it is put over the fire, and gently heated at first, and, as the heat is increased, the colour will vanish. When it has been in a sufficient time, they let the fire out by degrees, and do not take the stone out till it becomes lukewarm. If it is not entirely deprived of its colour, they repeat the operation, as before: for, if it was to be heated suddenly, or, when hot, immediately exposed to the cold air, it would certainly crack, or perhaps break entirely. A topaz is more fit for this purpose.

pose than an amethyst; for this has been managed so artfully, that it could scarce be distinguished from a diamond by the best judges.

We shall not here mention the different sorts of diamonds, as are described by Pliny, and some other authors, as they are entirely unknown to the present age, who acknowledge but one sort, unless those that are faulty may be said to be of different kinds.

They sometimes receive their names from the places where they are found, as the Hungarian, Bohemian, and the like. Among these there are two differences worth observation, for some are found in the form of hexagons, and others almost round, but they differ greatly in hardness: those that have angles are softer, and are little better than crystal, and such are the Hungarian. Those that are round, and in some measure resemble flints, are by much the hardest, and come pretty near the sparkling and lustre of oriental diamonds; but, as they will not stand the trial of the mastic, before mentioned, they cannot properly be called diamonds. The oriental diamonds are distinguished by the names of those places where they are found, and some of these are denominated from the old mines, and others from the new: however, they are not all equally hard, nor of the same colour, though they may stand the test of the mastic; and the harder they are, the more they sparkle.

Diamonds are not weighed like gold, but by carats, each carat consisting of four grains; and it has been said, that there was one found in Bijnagar, that weighed an hundred and forty carats, that is, five hundred and sixty grains. It has also been reported, that there was one met with which weighed two hundred and fifty carats, and was of the size of a pullet's egg. Tavernier likewise affirms, that one belonging to the great mogul weighed two hundred and seventy-nine carats. However, the largest now known in Europe is one that belongs to the great duke of Tuscany, which weighs an hundred thirty-nine carats and a half, and that in the possession of the king of France, which is equal to an hundred and six carats.

Diamonds

Diamonds are of such a nature, that no fire will injure them; for, when they have remained in one for several days, they rather come out with a more perfect lustre than otherwise. The value of it arises partly from its sparkling and reflections, (for it will imitate all the colours of the rainbow) and partly from its hardness; from whence it may be said to be almost incorruptible. Diamonds were formerly worn by kings and great persons only, perhaps, principally owing to their being so much dearer then than they are now. Formerly, a well-polished diamond, of the weight of a pepper corn, was sold for fifty shillings, which now is not worth above two.

With regard to the use of this valuable gem, it not only serves for ornament, but, when reduced to powder, is extremely serviceable for cutting and polishing all other gems whatever, and it is well known that diamonds themselves cannot be properly polished without it.

A diamond seems to consist of several plates laid one against another; for which reason a skilful lapidary, with the point of a knife, can divide one into two or more tables. If one be placed in the focus of a burning-glass, with its plates perpendicular to the rays of the sun, it will receive no detriment; but if it be turned the other way, the rays will get between the plates, divide them, and afterwards turn them into a glassy substance, leaving not the least sign of the splendor of a diamond.

The places from which diamonds are brought, are the island of Borneo, and the kingdom of Visapour, Golconda, and Bengal, in the East-Indies, as well as from Brazil in South America.

Tavernier, who travelled to the East-Indies chiefly for the sake of diamonds, visited the places where they are mostly found, in order to get the best knowledge of them he could. The first mine that he saw was at a place called Corfiatica, in the dominions of the king of Visapour, and at a place called Raolconda, five days journey from Golconda. This was found out about three hundred years ago; and about the place where the diamonds are met with, the ground is sandy.

dy, and full of rocks and low trees. In those rocks there are several veins, sometimes half an inch, and sometimes an inch broad. The miners have small pieces of iron crooked at the end, which they thrust into the veins to draw out the sand or the earth, which they put into vessels; and it is among this earth that they find the diamonds. As these veins are not always straight, but sometimes ascend, and sometimes descend, they are obliged to break the rock to follow the course of the veins. After they have opened, and gathered as much sand as they can out of these veins, they wash it two or three times, in order to discover whether there are any diamonds among it or not. This mine yields diamonds of a very fine water, but they are often flawed by the bad management of their hammers, in breaking the rock to pieces.

If the diamond is good, they only polish the surface a little, because they are afraid of bringing it to a proper form that would lessen its weight. If there be the least flaw or foulness, they give it a variety of faces, or sides, in order to hide the defect. However, it is observable, that they had rather see a black than a red speck in the stone; and therefore, when there is one that is red, they put it into the fire, and then it becomes black.

There are several men here, whose sole employment is to polish the diamonds, and they have each but one wheel, which is made of steel, and about the diameter of a pewter plate. They apply but one stone at a time to the wheel, and they sprinkle it constantly with water, till they have found out the way in which it will best work. This being found, they take oil, and the powder of diamonds, which they never spare, because it is cheap here, that they may polish the diamond the sooner. There is always a boy to attend them, who constantly supplies the wheel with oil and diamond powder. However, after all, they cannot polish the stones so well as the lapidaries in Europe; because, as it is necessary to keep the steel rough by applying emery, or by filing it, they are too lazy to do it so often as they ought, and consequently the wheel will not perform the work so well, nor so soon,

as those in this part of the world, where they take more pains.

We have been the more particular in the description of the diamond, as it is an ornament worn and admired by our fair readers. We cannot, however, but wonder, that they should condescend to bear on their heads and bosoms a rival, which may, in some measure, be considered, as equal in lustre and beauty with themselves.

The carbuncle is a stone of a very deep red, with a mixture of scarlet, and has been formerly thought to shine in the dark like a lighted coal; but it is now known to be otherwise. Suffice it to say, that this stone is very uncommon.

The ruby is a transparent gem, of a reddish colour, with a small portion of blue, and cannot be touched by a file. The redness is not like that of vermilion but of blood or cochineal; but the less blue it has in it, the better it is. They are found in Pegu, in a river of that name. The inhabitants try their goodness with their teeth and tongue; for they judge those that are the coldest and hardest to be the best.

The garnets have by some been taken to be carbuncles; for, when exposed to the sun, they will shine like a lighted coal, and much better than a ruby. They are brought from the East and West Indies.

The hyacinth is so called from its being of the colour of a flower of that name, which is of a yellowish red. This is the produce of the East and West Indies, as well as of Silesia and Bohemia.

The amethyst is a transparent gem, generally of a violet colour, arising from a mixture of red and blue. There are several sorts of this gem; but that is best which shines most like a carbuncle, and is so hard, that they may be turned into a sort of diamond, that may deceive the most skillful lapidaries.

The sapphire is a hard gem, of a blue or sky colour, is very transparent, and sparkles very much; but some of them are whitish, and others of a deeper blue; and, when they are destitute of all colours, they are called white sapphires, and are so like diamonds, that they may very well supply their place.

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The opal is a most beautiful gem, for in different lights it will shew all sorts of colours, as blue, purple, green, yellow, red, milk-white, and black, which is occasioned by the different refractions of the rays of light.

The emerald is a green, shining, transparent gem, and has a very agreeable appearance.

The cornelian is generally of the colour of raw flesh. This stone was in common use among the ancients, especially for seals, as it is at present among the moderns.

The onyx, which in Greek signifies a nail, is so called from its likeness to the colour of the nail of a man's hand. It is seldom transparent, and generally consists of a mixture of black and white, which are quite distinct from each other.

The agate, (of which there are many sorts) is very like an onyx, with regard to colour, but it differs from it in being adorned with zones, whereas the agate has none.

The chrysal is the most common stone of all those which are pellucid. There are some of them, which have been found in Alençon and Medor, that bear some resemblance to the diamond.

Let us now proceed to the more common stones, viz. those which are made use of in building. Those, with which we are most familiarly acquainted, consists of various sorts, as soft, hard, smooth, and rough. These stones alter both their grain and colour, not only in the several countries to which they respectively belong, but in the several beds or layers in the same quarry.

The other common stones are the sandy, or brown free stone; the mill stone; the chalk or lime stone, which is easily calcined; the whet-stone, which is a species of the brown free-stone; and the flint stone, which can never be cut perfectly even, and which emits sparks of fire, when struck either against a piece of steel, or a stone of the same species with itself. But the most grand and pompous of all common stones is the marble, whereof there are various species, viz. the white, the black, the black Ethiopian marble or basalt; ;

basaltes; the Lydian black marble, or the touch-stone, so universally used by the goldsmiths; the green marble; the granite, which is extremely hard; and abounds with a variety of spots, some green, and others white; the porphyry, which is highly esteemed, not only for its surprising hardness, but the beauty of its colour, which is that of a bright red; and, in a word, marbles that are veined with a vast variety of the most beautiful colours. The alabaster, both that which is perfectly white, as well as that which is veined, is likewise a species of marble; and the only difference between this and the others is the softness of it, which renders it more easy to be cut. But, to enumerate all the subordinate species of stones, would be an endless piece of work, since their number is infinite. Let us proceed, therefore, to enquire, how a block of marble, a flint, or a diamond, is formed in the bowels of the earth.

There are three several kinds of petrifications, which we are thoroughly acquainted with, and which may enable us, as they are obvious to sight, and easily conceived, to form a right judgment of the manner in which all others are performed.

Of the first sort is the stalactites, or that cylindrical congelation, which is formed, like an icicle, in the long crannies of vaults or caverns, out of the particles of sand that are carried away from the beds there, by the passage of the waters through those crannies; and these are amassed, by degrees, into a lesser or greater body, according as they are successively covered with fresh surfaces of the same sandy substance.

The second sort of petrifications, which we are likewise thoroughly acquainted with, are the crusts of stone, which the water of some springs fixes, by little and little, to the pipe through which it passes; and these are almost every where to be seen. From these it plainly appears, that the matter of the petrifications, let their nature be what they will, is driven by the water to the sides of the pipes in small particles, which, being applied to each other without any regularity, forces the water itself to turn from the centre of its course, to make a passage for itself; because the stony matter is applied as it were by chance.

The third sort of petrification, which is equally obvious to our observation, are those pieces of wood, those shells, or other petrified substances, which we frequently meet with under the earth, or in some particular springs, and which never lose their original form, or indeed any single lineament. In order, therefore, to explain the manner, in which these three sorts of petrifications are accomplished, we will suppose the first to be performed by thin plates, or leaves; the second by small masses, or lumps; and the last by insertion.

The substances by which these matters are brought about are water, salt, oleaginous juices, sand, clay, and loam. The water itself is but a very insignificant ingredient, if any, in the composition of stones: it is the water's province only to bring together, and mix the other materials of which they are composed: and the natural formation of stones is performed much after the same manner as the artful structure of our houses, wherein the water contributes to the intimate union and settlement of the materials; after which they grow harder and harder by degrees, as the water drains off.

Our three different petrifications are performed likewise by minute masses or lumps, and a very fine cement. The masses to be incorporated are the sand, clay, and loam; the most durable cements are the salts, and the several kinds of bitumen. Sometimes the salts, intermingled with the clay, serve as a cement for the sand; at other times, the mass is composed of clay, or loam alone, without any intermixture. From the different degrees of these several bodies, thus differently intermixed, proceed a vast variety of productions. It is the water that brings all these particles of matter by degrees together, which, upon its draining away, condense into solid and substantial masses.

We may range the slates, the talcs, the amianthus, and the parget or plaster, under the first sort of petrification. Chrystal is nothing more than a mass or collection of sands, of a pyramidal, or, probably, of a triangular form, which are successively incrustated by the water, and cemented or joined together by a small

small quantity of salt; and some very fine light earth. And we are the more fully convinced that this is matter of fact, because, when a chrystal has been dissolved by fire, there remains nothing but a small quantity of sand, earth, and salt. It is no such matter of astonishment, that a clear and pellucid mass should be formed out of sand, since, when we examine the several particles of it through a microscope, each of them appears like a transparent chrystal. The earth, with which it is intermingled, prevents its glittering like a diamond.

It is easy to be conceived, how a descent, or fall of water, may deposite, in any one particular place, a thin stratum or layer of sand and earth, of a blackish cast: as also, how a second descent of the same fluid may lodge another stratum, of the same substance, on the former; and thus, in process of time, form strata of a different thickness. From strata, or thin plates, like these, of various sorts of matter, are composed various sorts of stones.

The second sort of petrification, is that which is accomplished by little globular particles singly, or in lumps or clusters. All precious stones, we may presume, are formed in the same manner. They lie, for the generality, considerably deep in the apertures or crevices of some particular rocks, to which the water can only convey a small quantity of sand and salt, some drops of bitumen, and sometimes, by chance, a few metallic particles. These minute clusters, or lumps of matter, when they once begin to consolidate, form themselves into stones of different grains. If the clay or loam predominates, they are then opake. They are either veined, or studded with spangles of silver or gold, according as some particles of those different metals are casually intermingled with them; and, in fine, they are clear and pellucid when they are cemented, or bound together by the bitumen, or the finest sorts of sulphur, together with an intermixture of some salts, and some grains of the finest, most uniform, and brilliant sands. When the angles of the sand are in close combination, and the most minute particles perfectly fill up the intermediate spaces of the

larger grains, such stone may be truly said to be in its utmost purity and perfection. If, however, there be a vacant space between the angles of some grains, and the surface of others, such vacancy is an imperfection in the stone, and diminishes the worth of it. Its value is still farther lessened, when in this fine sand there happens to be an intermixture of some heterogeneous matter.

The structure of irregular flint-stones, and other stones which abound with fiery particles, seem to be the same as the formation of precious stones. The water meeting with several interstices, some larger than others, in its passage over marl, clay, chalk, or rock, lodges in those intermediate spaces the saline particles, the oleaginous juices, and the fine sands which are carried away by its action upon them. This water afterwards evaporates. The sand, and every thing else that is deposited in such vacant spaces, consolidates as in a mould, and the lump or mass bears the impression of the vacuum in which it is cast. When it is a fine sort of sand that predominates, the stone is more or less sharp and pellucid, as almost all sorts of precious stones are; its colours are dull and lifeless, variegated or veined, in proportion to the greater or less quantity of other matters that are intermingled with it. If there happens to be in the composition a great deal of salt and sulphur, which are such substances as have a strong flavour, and abound with fiery particles, the stone will emit a sulphureous smell when broken, or will send forth several sparks of fire, when struck against either another stone of equal hardness, or by a piece of steel; the violent percussion whereof opens those little lodgments in which those fiery particles were locked up, and by that means releases them at once from their confinement. If such mass has no electricity, notwithstanding the fiery particles that are contained in it, the reason is, because those corpuscles of fire are surrounded with earthy particles, which prevent or lessen the force of action, as a piece of lint wrapped round a glass, or fastened to the string of any musical instrument, will obstruct both the vibration and the sound.

Let us now proceed to the last and most common sort of petrification, which is performed by penetration. A large stratum of sand, clay, or other matter, may be petrified by those salts, and other sediments, which are injected by the water in its passage over it. And notwithstanding such water, with all its salts, will insinuate itself into a body of gravel, or sand, that is too porous to separate the one from the other, yet it will by slow degrees fill up the interstices or pores of a more solid body, and cement all the pores of it together. By this means a large layer of fine sand shall be sometimes converted into a mass or lump of brown free-stone. A bed of earth and sand shall likewise be transformed into a stone that is harder or softer, according as the particles of loam or sand are predominant in its composition.

Marl and clay, intermixed with sand, will change into marble, the ground whereof shall be either white, green, or black, according to the nature of the petrified stratum. The ground or base of this marble may be, in all probability, nothing more than a body of the finest sort of sand, into the pores whereof the water has introduced, at sundry times, some little sediments of marl, and some simple particles of clay, which in process of time may consolidate, and be converted into marble, whose species, colours, and intermixtures, may vary without end. If such clay has been dried and chapped by some subterraneous fires, the particles of fine sand, marl, or other matters, which the water in its passage lodges in its crevices, will form therein a multiplicity of veins of oil colours, and of various shapes. Several little spangles of gold, or other metal, which are fine enough to be carried thither by the water, prove an additional embellishment to those variegated colours. The drops of oil, with which the water is charged, form, by spreading themselves round about, an infinite number of little spots, which become round, when no ways obstructed; oval, when they are attracted by others sideways; and angular, or of a thousand other shapes, according to the embarrassments which they meet with. All these little veins, which thus irregularly wind and turn about, and which we sometimes find studded with

spangles of gold, or some other inexpressibly fine particles of matter point out, in a marvellous manner, the different routs and meanders of the water through the whole body of the stone. The various kinds of matter which the water carries along with it, being specifically heavier than the water, must unavoidably sink down to the bottom, and lodge in the first cavities which are large enough to receive them. The structure of a piece of marble may aptly enough be compared to the weaving of a piece of cloth or tapestry hanging: the body of the sand or loam, into which the water insinuates itself, is the warp, as it were, of the work: the water is the shuttle, that passes backwards and forwards without the least interruption. The fine sands, the sediments of the loam, the particles of the clay, and the small filaments or threads of metallic bodies, are jointly or separately the woof which is introduced into the body of the work, and in process of time completely fills it up.

There is no other way to account for a vast variety of uncommon and extraordinary petrifications, which are to be met with from one end of the world to the other, than by supposing, that what influence the water has in *great*, by diffusing itself over the different layers of matter which are extended under the earth, the same influence it has in *miniature* over pieces of wood, ivory, bone, or any other matter whatsoever through which it passes.

Whether there was a general earthquake at the time of the flood, which altered the face of the earth, by an elevation of those lower grounds the seas was in possession of before, and by a depression of the more exalted parts which were inhabited by men; or, whether the Almighty only altered the situation of the waters, by settling our places of residence in that part of the world which before was occupied by them, and sinking our eminences, in order to their becoming a new harbour for the ocean; we have incontestible proofs, that all places and countries whatever, now inhabited by mankind, as well the smallest islands as the most extensive continents, as well the mountains as the plains, and subterraneous caverns, were all once watered by the sea. What way soever this inversion of the earth by the flood was accomplished, the result of it, with

with respect to the matter of petrification, was this: several marine bodies of all species, covered by such desolation of the earth, in process of time became petrified by the insertion or penetration of such waters, salts, and several other minute chrystalline, or stony particles, as were qualified to fill up the pores of those bodies, without creating the least change or variation in their figures. By this means an infinite number of stones were produced, which, on account of their odd and irregular shapes, gave room to some whimsical people to imagine, that some of them had peculiar charms and inherent virtues, and that others were the products of nature in one of her gay and wanton moods.

Besides the bones of crocodiles, the skeletons of sea-horses, and the perfect bodies of petrified fishes, there are not only a vast variety of shells of all sorts to be found almost every where, but the various parts of sea animals, which are converted into stone. Of these, some excite our curiosity by the manner of their situation; and others, by the oddness or peculiarity of their figures.

Stones are frequently found, on the surface whereof are painted, as it were, in the most lively manner, several plants in their utmost degree of perfection: and the reason is, because the juices, which glued the plant to the stone, insinuated themselves so far into it, as to remain no longer a separate body, preserving only the traces of the former. Those figures which we find most commonly on stones, are the sea-mosses. As the bottom of the sea is always covered with them, we may reasonably imagine, that after the general inversion of substances, created by the flood, the impression of these sea mosses were frequently stamped on such petrified bodies, as were found in those places which the sea had abandoned.

There are stones, on which are represented, in the liveliest manner, the figure of a star. This is probably either a mass or lump of earth, that has received the impression of a testaceous sea animal, called the star fish, or else the fish itself converted into stone, together with some small part of the earth that adhered to it. There are sundry kinds of them, which nearly re-

semble the various species of those sea stars. Some of these petrified bodies, when dipped in vinegar, will seem at least to stir and move about. The cause of which is, the points of the acid whereof the vinegar is composed, by their penetration into the pores of the stone, introduce into it a much warmer air than that which was pent up in it before. This new air being instantly expanded, and endeavouring to release itself from its confinement, creates the tremor in the stone which gives the spectator such an agreeable surprise.

In Florence, as well as in some other countries, there are pieces of stone or marble frequently found, in which, after they have been polished, some can see at once, or at least think that they see, the ruins of an antiquated building, or the agreeable prospect of a spacious forest. These, however, are imaginary figures, only like those which some discover in the clouds, or like the trees which seem delineated on our windows in a frosty morning. For the formation of one of these Florentine stones, it will be sufficient, that the several small pieces of chalk, in any shape whatever, fall down upon a bed of earth intermingled with clay or loam. After the whole is petrified, and coloured by the descent of such water as is stained with vitriol, cinabar, or any other matter whatsoever, we find by experience, that if such petrified body be cut into thin plates or layers, these pieces of chalk are inverted, or oddly disposed, like the ruins of an antiquated building. Let the lapidary after this cut out the stone in so artful a manner, as that the imaginary ruins shall all appear below, whilst the upper part, when polished, is varied with fortuitous veins of divers colours, a lively imagination will instantly discover skies and clouds hanging over the ruins. If in such petrified chalks there should happen to be some few ramifications of metallic particles, it will be sufficient to create a new discovery of a parcel of little plants springing out of those ruins.

It would be unpardonable to quit this subject, without taking notice of a very curious petrification found in White-Friars in February, 1763. The learned and

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ingenious gentleman, who luckily discovered it in passing along, where some workmen were repairing broken pipes, has obliged the public with the following particulars:

"It is of an oblong figure, between round and square, about a foot and a half in length, and near nine inches thick; weight exactly ninety pounds. From its form it looks as if it had originally been a post to keep off the carts. Its upper surface, which lay level with the superficies of the pavement, is of a brown colour, resembling the other stones in the street, and therefore, when coloured with wet and dirt, it is no wonder should so long have escaped the notice of every observer, though hourly passed over by all who went that way. The lower part, that dis-^{lay}ay, that which lay lowest in the pavement, seems nearly of the same colour, excepting that the firm of the wood is more easily distinguishable in it. One side is covered with a sparry incrustation, of a white glittering colour, breaking easily into flakes, and as easy to be reduced into powder, as not unlike, in short, to the salenites, or some kinds of alabaster. This does not seem, however, to have formed originally any part of the wood, but to be rather a stony coat or excrescence generated by the water, which affected the petrification. The other side consists entirely of the petrified woody matter, and, by the cavity formed in it, seems to have rotted away in that part before its petrification. As to the two ends, they are, to all appearance, perfectly stone."

Though we have already endeavoured to explain the cause and manner of petrifications, yet we shall here subjoin this gentleman's opinion of that just described.

"It was found close to a water-pipe, where it had probably remained many ages with the water continually exuding upon it; but that the water there formed the petrification, is a point not to be admitted, on account of the sparry coat, which will not admit of its having been petrified by fresh water. But even should this be granted, it would be still necessary to enquire what water did it; for, though the water of

the plug, near which it lay, was continually exuding upon it, yet as both rivers water run that way, its petrification might have been owing to the other. It is well known, moreover, that the Friary is, for the most part, an artificial ground, abounding in springs, some of which have been formerly reputed medicinal *; and, if any of the waters of these springs came near it, I mean so as frequently to moisten it, in that case it is to be attributed to them, rather than to the river waters. What renders this point also clearer is, that in the great use that has been made of the two river waters, we have never heard of any petrifying qualities being attributed to them."

Our fair readers are, we presume, by this time become pretty well acquainted with a considerable part of those bodies, which are deposited by providence in the bowels of the earth for our convenience and advantage. We have endeavoured to explain, in the words of one of the best authors who has wrote on this subject, the manner in which the sands, salts, loam and clay, by the action or impulse of the water, concur in the formation of those masses of stone, according to the wise purposes for which they were ordained: let us now enumerate some of the principal benefits and advantages which accrue to us from all sorts of stone, both precious and common.

Whether those medicinal virtues, which are by many ascribed to them, be real or only imaginary (which last is most probable) we will not determine, but content ourselves, at present, with expatiating on their surprising hardness and radiant lustre, for which they

* "The memory of this medicinal quality of the water is still preserved in the name of a court there, called Dogwell-court, which, though improperly set down Dodwell, in the City books, as if it had formerly belonged to one Dodwell, as proprietor, yet it is well known took its name from a dog's accidentally falling into a well, which is still to be seen in the cellar of the upper house in the court, and being thereby perfectly cured of a most inveterate mange. From this accident the well grew into very great repute, insomuch that, in monkish times, it was prodigiously resorted to by persons afflicted with cutaneous disorders; but since the dissolution of the monasteries under Henry VIII. has been noted for nothing more than the tradition of its former virtues,"

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are universally admired. However, be their inherent qualities what they will, the reputation they have gained on account of their salutary virtues, has produced them the honour of being worn on the finger, and esteemed, in some cases, as an amulet or preservative against some epidemical distempers. Though there are many, who probably have been disappointed in this respect, yet they have found out the secret of making them really serviceable in another, viz. by engraving their coats of arms, or any other particular figures upon them, and by that means using them as private seals, or little pocket impressions: an invention, which is, doubtless, of great importance to society in general, since it gives a sanction to what we convey to our absent friends, and in the same state in which we sent them.

As to those stones which are of a monstrous size, and are frequently met with in subterraneous caverns, could any one believe that such unpolished, cumbersome, and shapeless masses of matter should be capable of being cut, removed from their original station, and be ranged in such a regular manner, as to form those buildings, which are as lasting as they are grand and magnificent, and as secure as they are healthful and commodious!

When the descendants of Noah were reduced to the necessity of dispersing into distant countries, in order to seek out commodious settlements for themselves and their families, they found every place over-run with woods, and inhabited by an infinite number of savage beasts. By the help of a few boughs, and the skins of such beasts as they killed in the chase, they erected at first a few huts or tents, which served to shelter them from the injuries of the weather. As they were not however, at that time, equally safe and secure from the violent attacks of those devouring beasts, nor from the merciless insults of their more savage fellow-creatures, what a peculiar providence was it for them, who as yet lived in a restless uneasy state, to find under their feet, and at a moderate distance from the surface of the earth, such immense quantities of matter, that was soft enough to be cut and fashioned according to their

their pleasure, and yet so solid at the same time when exposed to the open air, and disposed in a proper manner, as to secure them not only from the most outrageous storms, but the insults of their private enemies; and, at last, to defend whole kingdoms from any hostile invasions.

By this means, in process of time, both villages and cities arose out of the earth, and men attained to the art of lodging and cementing the most unwieldy stones in the closest manner; of building for themselves commodious habitations, impregnable fortresses, and magnificent places for the reception of their rulers and princes; and, in fine, those solemn and pompous temples, in which all the families then on earth met together at stated times, to pay their tribute of gratitude and worship to their common parent, to visit one another without pride or respect of persons, and to lay themselves under the most solemn engagements inviolably to perform all those good offices one towards another, on which the welfare of an amicable society entirely depends.

Another benefit which arises from those solid subspaces, which Providence has vouchsafed to lodge for our service in the bowels of the earth, is that of paving out highways, and by that means securing to ourselves both firm and passable roads in the worst of weathers. This is an article wherein the convenience and beauty of the most populous city in a great measure consist. The whole Roman empire, by this contrivance, appears but as one extensive city, the pavement whereof extends from one end of it to the other. Rome was the centre of a prodigious number of magnificent highways, which ran through all Italy: several of them traversed the Alpine hills, the country of the Gauls, the Pyrennees, and the whole Spanish dominions. One of them in particular was carried from Rome to Lyons, from thence to Rheims, and from thence again to Calais. It was carried forward again in England, and reached as far as Scotland. That which was extended as far as Bizantium, was continued from Chatecdonia through Asia Minor, Syria and Palestine, from thence it winded through the isthmus

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of Suez, in order to pass through Egypt, as far as Syene, and from thence into Ethiopia. There were several others all along the coast of Africa; and, in all probability, the Romans borrowed the plan of their paved roads from that of Carthage.

When we compare our modern pavements with those of the military ways of the Romans, how contemptible does the former appear. What a miserable figure do our common pavements make if neglected for ten years, many of them in a less number of months, while those of the Romans have continued whole and entire for these fifteen hundred years! the reason, however, is very obvious, we are very little attentive to the foundations on which we pave. Though the Roman highways are in some places shattered and demolished, for want of timely repair, yet there are several countries where they still continue good, and as whole as ever. The Appian way, which was at first carried from Rome to Capua, and from thence to Brundisium, is still whole, even and sound, notwithstanding it has been a highway near two thousand years.

Should our fair readers wonder, how it were possible for the Romans to erect so many and such extensive highways, which reached as far as their victorious arms, we are at a loss to conceive how their admiration will be increased, when they come to read what labour and pains they bestowed on them. The ingenious Mons. Bengier, counsellor at the court of Rheims, wrote a curious and learned treatise, under the title of *The History of the Highways of the Roman Empire*. In which he treats this subject in the most masterly manner, a subject that is, indeed, too little regarded.

But, to proceed, the long duration of these highways can be imputed only to the particular manner in which they were built. In the first place, they opened two parallel furrows with a plough. Then the Soldiers (for they were the principal persons employed about such public works in times of peace) removed all the light earth which was thrown up between the furrows, and dug till they came to a solid and

and substantial bottom. After this, they filled the trenches, which were so hollowed, with a more gross and compact matter, that is, with a kind of hard sand, or gravel, dragged out of the nearest rivers, or extracted from the adjacent quarries. The fosses thus covered, were rammed hard down, and laid level with rollers of an immense weight. These precautions, however, were not thought altogether sufficient, for they would frequently (in order that the water might drain off with the greater ease, and that the mud or dirt might gain no admittance, which, by soaking in, would doubtless very much damage, if not undermine and demolish the whole) erect a terras or causeway some feet above the surface of the plane, which consisted of four beds or strata, of the strongest and most substantial brick-work.

Let us now proceed to enquire how this is effected, wonderful as it appears: on the earth so firmly compacted, and laid smooth or level as before mentioned, they spread a crust or covering of cement, composed of lime and sand, or soft gravel-stone, of about an inch in thickness. The first coat or stratum which they laid upon the cement, consisted of large flat stones lodged one upon another, about ten inches deep, and cemented with the strongest mortar. Such stones as were larger than ordinary, were disposed along the borders or sides of the causeway.

The second bed or stratum was composed of stones, some whereof were of a cubical, round, or oval form, and others rough and unhewn, but sometimes intermixed with pot-sherds, and small pieces of tiles and bricks. This compound was spread with a shovel over the first layer of stones, and rammed hard into the cement, which kept them firm and close together. This second layer was usually eight inches thick, or thereabouts.

The third bed or stratum consisted of a cement of about a foot in thickness, that was made of chalk, sand, or hard gravel-stone, intermixed with lime, according as either of those materials could be procured with the greatest ease. The only reason why it was never made of powdered tile, was the great expence
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that attended it. This coat or covering, which by some was distinguished by the name of the pudding or paste, and by others the kernel, filled up all the interstices or immediate spaces in the strata below, and settled into a hard smooth incrustation. As it is so difficult to be broken asunder even now, it must of necessity have been a very substantial support to the upper layer, especially since the inferior coats are so exceeding hard, with which it is blended in so firm a manner, as to form one solid mass or body, on which no weight whatever can make the least impression.

The fourth and last bed or stratum, which was called the incrustation, was sometimes composed of large flat stones, as in the Appian way; and at others of gravel, or small flint stones, intermixed with sand or gravel, as in the greatest part of the military ways. Such stones as were hardest, the free-stone and large flints, were generally set apart for the pavement of the most populous towns.

We should, indeed, be at a loss to conceive, how it were possible to collect materials, flint-stones in particular, for so vast a work, had we not been informed, that the country people were obliged, by an edict, to collect all the little flints they met with in their vineyards, waste-grounds, and ploughed lands, on the banks of rivers, or on the sea-coasts, and to deposit them in large heaps by the road sides, whence the soldiers might take them as occasion required. The third layer was convexed six inches thick with these materials, and secured on the sides with two margins or borders of earth, which were sometimes fortified with large massive stones, but always lay on a descent, whenever the causeway was raised above the plain. By this advantageous situation, no water could have time to insinuate itself into the gravel, and by that means either loosen or impair it. Thus much for the Roman pavements.

To conclude, besides the advantages already mentioned, arising to us from the use of stones, they are still further serviceable, in furnishing us with proper materials for erecting everlasting monuments in commemoration of our most illustrious heroes, and their
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glorious achievements. We had been perfect strangers to the history of the world, had it not been for stones and medals. It is by their aid and assistance, that we are intimately acquainted with the names, lineaments, and remarkable transactions of such princes as flourished near two thousand years ago. The molten brass, or the hardest marble, when under the hand of an artful statuary, assumes the form of Alexander or Socrates, Caesar or Virgil, Marlborough or Milton, Wolfe or the great Sir Isaac Newton. By virtue of this most excellent art, we are capable of reviving, as it were, and setting before our eyes, those patriots, who long since cheerfully died in the defence of their country: and it was, no doubt, the principal intention of the great inventor of this art, to animate us in the pursuit of fame, by setting before us the shining examples of former ages.

CHAP. IV.

Of Minerals.

WHAT we before observed of fossils, may be here said of minerals, that, were we to treat of them as copiously as they deserve, we should greatly exceed the limits of this work, and trespass on our intended brevity: we must therefore content ourselves with describing the choicest and most useful minerals, of which gold stands the foremost.

The preference which we give to gold above all other metals, is by no means the effect of prepossession or caprice: the superior regard which we pay to it is grounded on its intrinsic and inherent merit. There is no metal so solid and compact, so weighty, or refined to so great a degree of perfection: it is, beyond all contradiction, of the most beautiful colour, and comes nearest to the radiancy of fire: it is the most ductile and most obedient to the workman's hand, of all metals whatsoever: it never soils or besmears his hands, as any other metal will. The least particle
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of it gives an additional grace to every thing it touches. It has one other excellent quality, besides those already mentioned, and that is, it never rots, or loses any thing of its weight while refining in the fire.

It is nothing surprising, that mankind should unanimously agree to fix upon a metal of so pure, solid, and durable a nature, in order to pay for, and procure such various accommodations as they indispensably wanted. Before the discovery of this precious ore trade and commerce were carried on by way of barter; wine, for instance, was exchanged for oil, corn for flax; one commodity, in short, was mutually agreed to be accepted for another, as occasion required. This method, however, of negotiating business, was attended with a thousand inconveniencies. Two contiguous nations or provinces might, possibly, be overstocked with the same commodity; or supposing the product of their ground to be different, yet it created abundance of trouble to make a just computation of their real and intrinsic worth, inasmuch that it was no easy matter to adjust an equivalent in the wholesale trade, though practicable in the retail way; and men were obliged, though often with reluctance, to dispense with many things, for want of such accommodations as were agreeable to those who were possessed of them.

Now gold, being a metal of a pure, ductile and incorruptible nature, was looked upon by them as the most agreeable and proper substance of which to make a general standard, and the most commodious equivalent that could possibly be given in exchange for all the accommodations and conveniencies of life whatever. And, as this radiant ore was very scarce, they agreed, with one voice, that a small quantity of it should be deemed a sufficient compensation for a large portion of any other merchandize. They wisely considered how advantageous a thing it would be for them, to be enabled, by virtue of a small portion of such precious metal, (which is little or no incumbrance to a traveller, and easily concealed by him from the notice or eyes of those who might otherwise be disposed to oppress him) to take a tour all round the habitable

habitable world, in order to furnish them with whatever conveniencies they wanted, and to defray all their necessary expences, without the least dependency, incumbrance, or enquiry.

This method of transacting business was found to be so expeditious and convenient, that, in process of time, the practice became universal. There was one little inconvenience, indeed, that attended it. Every merchant was obliged to carry his scales and weights in his pocket, in order to know the intrinsic value of what gold he received; but an expedient was soon found out to save him the trouble, by making little thin pieces of gold and silver, with some known and public figure impressed by authority of the government upon them, to settle and determine their real value, that he who delivered his goods might be well assured, that he received so much gold and silver, of such a weight and standard, in return.

As gold, however, was reserved, on account of the great scarcity of it, to discharge and pay off large sums, with the utmost expedition, they had recourse to baser and more common metals for their daily disbursements and their retail business. Having thus given a short detail of the origin of money, and the great convenience of gold, we shall proceed to enquire where this metal is found.

Gold is found either in mines under the earth, or among the sands of some particular rivers, though both are originally the same. It is very natural to suppose, that such little globules or specks of gold, as are collected in the sands of rivers, were carried away from such mines by the current of some water that passed through them.

The gold of the mines is either in little grains, or else in stones: the former is sometimes found in lumps or hard masses that weigh a dram or two, or thereabouts. The gold in stone, which is more frequently found than that in grain, is a hard mineral, that abounds, more or less, with little brilliant particles of this precious metal, which are confounded and intermixed with those veins of earth that run through the ore, and which constitute, in proportion to their dimensions,

mentions, the richness of it. These small grains, or little specks of gold, are frequently found closely adhering to rocks, marbles, or precious stones, according as the water has, by accident, carried these bodies away by its current, and intermingled one with another.

In order to separate the gold from the other heterogeneous matters, they first pound the mineral with iron pestles: after that they carry it to the proper mill for reducing it to powder: this, in the next place, is sifted through a fine copper sieve; then, by mingling a proper quantity of quicksilver and water with it, they bring it to a paste, and knead it in a wooden trough for two days together in a sultry sun. The quicksilver, by degrees, imbibes all the particles of gold that lie concealed in the paste, without laying hold of any of the coarse earth or sand, which is mingled with it, and lies in the water at the bottom of the trough. This sediment is discharged with all the ease imaginable, by only stooping the vessel, and letting it drop away. The mass, which then remains, consists of nothing else but gold, quicksilver, and a small quantity of the finest earth. This last is separated from the mass by repeated effusions of hot water. The mercury is disengaged from the gold by evaporation caused by fire. Thus there remains very little else but the gold. However, it is not absolutely pure and perfect as yet, there still remains some extraneous matter, either of an earthy or metalline nature, intermingled with it. In order, therefore, to complete the separation, they are obliged to have recourse to the most violent dissolvents. And this they call the *affinage*, or refining it.

Gold is sometimes refined by antimony, and at others by a sublimate; sometimes by aqua fortis, and, lastly, by lead and ashes.

Antimony is a kind of metallic stone, that, with respect to its colour, bears a near resemblance to lead ore, and which, when fused or dissolved, has the property of adhering to, and imbibing all fine earths and metals, that it meets with, gold only excepted, on which it takes no hold, but suffers it to subside to the

the bottom of the vessel in which the fusion is made.

Sublimate is an artificial composition of quicksilver and the spirits of sea-salt, which, when put into fusion with the gold, volatilize, and send off in exhalations all the foreign metals that are intermingled with it.

Aqua fortis is a liquid composed of such spirits as are extracted by fire from nitre and vitriol. This fluid has the property of dissolving silver, copper, and other metals, but not with equal ease: however, it leaves gold in its original state, without causing the least variation in its parts. Aqua regia, which is a strong liquid, with some sal gemma and sal ammoniac dissolved in it, is the only preparation which has spirits fine enough to melt down gold. The refiners prefer aqua fortis, for the most part, before it, because it absorbs all the other metallic matters that are intermingled with it, and never touches the gold, but leaves it pure and entire.

The parting, or separation of metals by aqua fortis is, doubtless, not only an invention that justly excites our curiosity, but demands the public thanks of all mankind: and the author's name, were it known, ought to be recorded in the books of fame, and be always mentioned with the profoundest veneration and esteem. Whoever he was, he lived, in all probability, about the close of the thirteenth century.

There is a fourth method of refining metals, and that is performed by the use of lead: we will, however, pass over this operation, and proceed to observe, how providence has endowed this magnificent metal, among all its other perfections, with ductility, by which means it is with ease obedient to the hand of the workman, and expanded to such a degree, that one leaf will serve to cover a very spacious surface. By virtue of this property, notwithstanding the great scarcity and value of it, men may afford to adorn their habitations with it, as if it was some more inferior metal.

Gold-beaters, and gold-wire-drawers, oblige us to admire their good conduct and economy; and it must

must be allowed, that their art is not only surprising, but a perfect prodigy; and, if we were not eye-witnesses of it, we should never be prevailed on to think it practicable. We ought not, however, to impute that to art and industry alone, which, in reality, is a bright display of the goodness of the great Author of nature. By one or two operations only, which this precious metal goes through, we may be enabled to form an adequate idea of its excellent qualities, and of its obedience in particular to the hammer.

A gold-beater puts three ounces of fine gold in a state of fusion, and reduces the mass, by working it on his anvil, to a plate as thin, if not thinner than paper. He afterwards cuts it into little pieces about an inch square. These pieces, in order still to be further enlarged, are clapped between the leaves of a square book, which is very carefully secured and wrapped up in a double case that is made of parchment. The book, in the next place, is laid upon a block of marble, and there well beaten with a massive hammer till the leaves of gold are extended to the size of the book, or very near it. They are then taken out, and cut into four equal parts, each of which is clapped again between leaves of parchment, and beaten again with the hammer. After they have been thus cut again and again into squares, and enlarged as before in the two first books, they are cut and hammered in two more, which are distinguished, as well as the former, by the name of moulds, with this difference only, that the leaves of the one consist of parchment, and those of the other of ox-guts worked perfectly soft and fine. By these expedients, a little plate of gold, of about an ounce in weight only, is hammered out into sixteen hundred leaves, three inches square, or into one thousand leaves four inches square. So that the surface of it is above an hundred and fifty thousand times larger than it was at first. The following operation, though equally common, is much more surprising.

A gold wire-drawer takes an ingot or bar of silver, of a cylindrical form, two feet and eight inches in length, and two inches and nine-twelfths of an inch in circumference. Upon this he spreads as many leaves
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of beaten gold as weigh, in the whole, exactly half an ounce. He then drives the extremity of this cylinder with force through a round hole that is made in a steel plate, the entrance whereof is wider than the other end, which is called the eye. When the end of the ingot of silver is drove through the eye, he lays fast hold of it with a pair of strong pincers, fastened to a substantial rope, which several men drag in by the help of an engine called a wire-drawing mill. After this the ingot is passed through several holes successively that are one finer than another. Thus, by slow degrees, it is reduced or drawn out to the minuteness of a reed, a tag, a coarse thread, and, at last, to that of the finest hair. Every time he works it through a different wire-drawing iron, he rubs it with wax, in order to facilitate the extension. It passes through an hundred and forty holes and upwards, before it acquires its utmost degree of fineness. By these expedients, an ingot of two feet and some few inches in length, and two inches in circumference, is extended into a thread, three hundred and seven thousand two hundred feet in length: nay, sometimes, an ingot of two feet in length, and three inches and four-twelfths of an inch round, is drawn out into a thread of one million, ninety-six thousand, seven hundred and four feet in length.

The most surprising part, however, of this operation, is this, that the half ounce of leaf-gold that first covered the ingot of silver, should, notwithstanding its former degree of fineness, grow gradually still finer and finer as it passes through the different wire-holes, and cover the surface of the silver so very exactly, as that no part of it whatever should be seen. It appears, in short, one entire thread of gold. Thus half an ounce of gold may be made to extend itself into a surface of above *seventy-three leagues* in length.

This thread is afterwards pressed into a flat, thin layer or plate, by being placed between two cylinders of polished steel that turn one over another. The thread thus made as flat as possible, acquires two surfaces equally gilt, each *seventy-three leagues* in length.

length. From whence it is evident that half an ounce of gold may possibly form, and often actually does, a superficies of an hundred and forty-six leagues in length. If then a man, notwithstanding the defects of his most artful instruments, can produce such wonderful effects on the works of the Almighty, how much more amazing, how much more excellent in their nature, must those works themselves be! Hence we may plainly perceive, that the internal nature of this metal, and, in all probability, that of all other substances whatsoever, is beyond human comprehension. We must at last have recourse to that undoubted truth, that the great Author of nature never intended that we should fully comprehend the innate perfections of his works, but that we should be at liberty to make use of them with decency and discretion.

Let us now leave this precious metal, and proceed to a description of others less valuable. Pliny, in discoursing on silver mines, assures us, that this metal, whilst in the earth, has no peculiar lustre, no distinguishing mark to point out its species. It is, indeed, frequently found in marcasites, sometimes of a reddish tincture, and at others inclining to a blue; sometimes, again, we are told that it lies in a kind of lead ore, from whence some men have, by practice and experience, been taught to extract it. That silver, however, which is lodged not only in the mines of Potosi in Peru, but in several others in America, as also that in the German mines, sparkles in the earth, and is with ease distinguished from any other kinds of earth, in the cliffs and beds of rocks. Sometimes it is found scattered up and down in stones, or sticking close to their external parts, as it were, in little ramifications. It is a very common thing to find silver in little masses or lumps, consisting of minute fibres, like a ball of silver-thread after it has been burnt. In a word, it is sometimes found in solid masses, without any intermixture whatsoever. Some weigh but a dram, others about an ounce, and some again several marks. In the reign of the emperor Frederick III. there was found in the mine of Schneeberg, which belongs to the house of Saxony, a block of silver of a surprising bigness.

Duke

Duke Albert had a great inclination to go down into the mine to see it; and, ordering an elegant entertainment to be prepared, and the cloth to be laid in form upon it, said to those who were invited to the feast, "Gentlemen, though the Emperor Frederick is, indeed, a very powerful prince, yet you must allow that he has not such a rich table to dine upon."

It will not, we presume, be thought any deviation from our present subject to observe, that marcasites, which are subterraneous masses of a stony substance, streaked with metallic veins, and, for the most part, disposed like so many radii, or straight lines meeting in one common centre, are more frequently found in silver mines than in any other whatever. The principal structure of these stones appear to be thus: when a small mass or body of earth, intermingled either with iron or copper, is by accident covered by a vitriolous fluid, that has dissolved and carried away with it some particles of silver, the acids of such fluids meeting with no obstruction, insinuate themselves into the pores of the iron and copper. One particle of acid salt immediately follows another. Those which are at the greatest distance, advance in a direct line, like little streams of water into a common reservoir. These acids, directing their course to the centre, when they are impeded, abandon the particles of silver, and range them all along those little channels through which they passed, in the form of so many radii, uniting in the centre of the mass. When these straight streams branch out into little divisions, then the marcasite appears streaked with little filaments or threads of metallic matter, which are irregular, and run in all directions. The first bed or basis thus laid, and thus petrified, if the mass should happen afterwards to be covered with another fluid, wherein there is a solution of some other metal, the acids of such new fluid act in the same manner as the first, that is, they abandon the silver to insinuate themselves into the pores of the former mass, and introduce with them those metallic particles, either of copper or iron, wherewith they abounded. From whence it of necessity follows, that the radii which tend towards the centre of the marcasite must
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be intersected with lines of various colours, which point out the various emanations of the metallic and other substances, which form those little incrustations or coverings, which surround the mass, and contribute towards its gradual augmentation.

As silver is extracted from its ore much after the same manner as gold, we shall not enlarge on that head, but proceed to say something of other metals.

There are two sorts of copper, the red and the yellow. When it is first extracted from the mine, and in its ore, whether of earth or stone, there are frequently found some small particles of silver intermingled with it. This is fused over the fire several times, in order to purify and cleanse it from all heterogeneous matter. After these repeated operations, it becomes red copper, which is the finest and most ductile. There are large quantities of it to be met with almost in all countries; the best, however, is brought from Sweden. When a mass of copper is fused with an equal quantity of calamy, which is a kind of cadmia, or fossil earth calcined, it is thereby considerably enlarged, and by such operation converted into yellow copper, or what is commonly called brass. Though this alloy, it is true, renders the metal less ductile, yet it is much more proper for several purposes, is less liable to rust; and, besides, its ductility can at any time be restored, by only softening it with an intermixture of lead.

Though this metal is not so frequently made use of as formerly in the service of the table, yet there are a thousand other ways of rendering it serviceable. Cisterns, caldrons, kettles, and, in short, a great part of the vessels made use of by our brewers, dyers, and several other tradesmen, are principally composed of either brass or copper; and so, likewise, is a great part of the furniture of our kitchens. However, as salt is almost inseparable from water, and nitre from the air (more particularly when diluted and attenuated by moisture) they insinuate themselves into the copper, which is very porous, and corrode it, and, by adhering to it, form a kind of rust or incrustation, commonly called verdigrease, which is a rank poison. It is customary, therefore, to line the insides of most of our

copper vessels with tin, particularly such as are made of red copper, which is of a softer nature, and consequently more susceptible of such impressions: the tin being more fluid and subtile, closes up the pores or interstices of those metals so exactly, that neither the air nor the water can lodge any of their salts within them. Red copper likewise, on account of its ductility, is obedient to the hammer of the workman, and wrought, without any great difficulty, into what form and figure he sees most convenient. This metal, however, is peculiarly useful in the art of engraving, as it renders the works of the most celebrated statuaries and painters universally known and admired.

Brass, or yellow copper, which, on account of its being intermingled with the *lapis calaminaris*, is more fusible than ductile, or obedient to the hammer, is principally employed in cast works, flows with freedom into any moulds that are prepared for it, and is very susceptible of any impressions. After that it undergoes the severe discipline of the file and the graver, and will glitter like gold, when polished with emery or putty, or burnished any other way.

As this metal, besides its good properties already mentioned, is solid and substantial, and not subject to decay through rust, or length of time, it is frequently transformed into lamps, sconces, candlesticks, and all sorts of pedestals or supporters, &c. &c. The incorruptibility of this metal induced the Romans to make the gates of their temples with the best-polished brass. The usefulness and excellency of this yellow metal, appear no where more conspicuous than in the mechanism of a watch. Two or three ounces of brass, together with a few steel rivets, in the hand of an artist, will form a little engine, that consists of two hundred different pieces, commonly called a repeating-watch, and lie at the same time within the compass of a case of about one inch deep, and two in diameter; and, what is still more wonderful, the teeth of this curious machine, though so very fine as not to be discerned without some difficulty by the naked eye, are so strong and solid, as to continue constantly in motion for three-score or four-score years successively, without suffering the

the least diminution or decay, and without deceiving you, with respect to your time, either night or day.

If we mix an equal quantity of red and yellow copper together, we shall form a metal which is called cast copper, or what we call bronze: a substance every way qualified to immortalize the names of illustrious heroes, and to perpetuate the remembrance of the most remarkable transactions; to preserve the portraits of our patriots for ages, after death has snatched them from us.

If to this yellow copper, or brass, we add a small quantity of tin and antimony, in order to facilitate its fusion, and to stop up all its pores, it is then duly prepared for the casting of cannon, mortar pieces, and several other destructive engines of war.

If we fuse it with half the quantity of tin, that is to say, if we add five-and-twenty pounds of tin to fifty pounds of cast copper, it then becomes musical and sonorous. The founders use it, when so prepared, in the casting of their bells, the sound whereof may be heard much farther than the loudest trumpet.

Let us now proceed to that common, but extremely useful metal, iron, which is taken out of mines, or holes in the earth, that are dug moderately deep, the external parts whereof are somewhat blackish, and extremely dry. In some the ore appears of a stony substance, which is pounded by large massive pestles, in order to be washed and melted: in others, it is intermingled with a kind of earth, or coarse sand, which is thrown into a flat tub, about ten feet square, and two feet deep. Through this, which is kept constantly stirring, runs a perpetual stream of water, that washes away the light earthy particles, whilst the ore, which is specifically heavier, sinks down to the bottom.

After every casting, which is constantly performed once in an hour and three quarters, the furnace is obliged to be supplied with a sufficient quantity of fresh coals and ore. These materials are afterwards covered with as much flux stone as they see convenient, without which the fusion would neither be so great nor so advantageous.

As soon as the ore is melted, it runs along the bottom of the furnace, which is built upon a descent, till it comes to a kind of flood-gates, which are drawn up, that it may descend in a liquid mass of fire into long trenches made in the sand, or into moulds of various forms; some whereof are set apart for cannons, mortar pieces, and other warlike stores; some again for chimney-backs and conduit-pipes; and others for kettles, coppers, &c.

When the iron is cold, it assumes a triangular form, and is then called a pig or bar of iron. In the course of the several operations, which it goes through afterwards, it is submitted to the violent percussion of an enormous hammer, which generally weighs upwards of six hundred pounds weight, the noise whereof has been distinctly heard above three miles off.

The conversion of iron into steel is a very common practice among the Germans, who have several furnaces erected for that particular purpose. In these they lodge all their iron that has before passed through the refining and annealing furnaces, and let it continue there till two-thirds of it, through the action of a very fierce fire, is wasted or consumed away. After this, it is put into the forge, and the remaining third is pure steel.

The method observed in the making of tin is a greater secret than that of making steel; for tin is nothing but iron-plates artfully tinned over. The iron plate, in order to be converted into tin, undergoes three very simple operations. In the first place, it is whitened in proper vessels, filled with water, and such vinegar as is made of fermented corn. In the next, after it is well rubbed with a sponge dipped in a glue pot, it is plentifully sprinkled with sal armoniac, or salt of tartar, reduced to a powder as fine as dust. In the last place, it is plunged for about half a minute, in an iron crucible, which is eighteen inches in depth, and filled with melted tin. After it has passed through these three operations, it is then distinguished by the denomination of a tin plate.

What we have already hinted, with respect not only to the nature of all the metals before mentioned, but to the method observed in extracting them pure and

perfect from their respective ores, by the operations of the washing troughs and the fire, is applicable in like manner to tin and lead. Tin originally is nothing more than a sort of white lead: it is too, like that metal, soft, ductile, and very weighty. Not only its properties, but its uses likewise, vary by an intermixture with other metals, as with molten copper or brass, or with other metallic substances, as zinc and bismuth.

We are taught by experience, to dilute these metals in such a manner as to make them all serve for such measures and vessels as we see most convenient. We make use of tin to line all our copper utensils, which, without that precaution, would soon be corroded with rust and an infectious nitre. A composition of this metal, intermingled with a proper quantity of mercury, is always spread over the reverse of our mirrors, or looking-glasses, in order that, by a proper reflection of the rays of light, they may represent all objects more faithfully and distinctly to our view. It is to a due assortment, or proper mixture of tin and lead, that we owe the structure of those numerous pipes which constitute the organ, that heavenly-musical instrument, of most exquisite invention, which by far surpasses all others for its perfect harmony, its length of sound, its vast variety of notes, its commands of the passions and affections of the soul; and, in a word, for its taking the whole compass of music within itself.

The principal merit, however, of lead and tin, is the peculiar use that is made of both in the casting of types or characters for those who follow the art of printing; by the aid and assistance whereof they multiply copies of books with the utmost expedition; and, by the distribution of them into their proper boxes, make them serve again for future purposes of the like nature: an invention of the utmost service and importance to mankind, as it conduces to our being familiarly acquainted not only with past transactions, but the tenets and opinions of the wisest men in all ages of the world.

Let us now, in the last place, say a few words more on the different qualities of gold and iron, with which we will conclude this book.

Though gold is, beyond all dispute, the most perfect of all metals, and though all others have their several good qualities, and particular uses to recommend them, yet that very metal, which to all outward appearance is the meanest and least polished, which abounds most with alloy, is of a dark and gloomy hue, and the most liable to rust, yet that very metal, iron, is more beneficial and advantageous to us than all the rest. It has one particular quality, which alone is sufficient, in some measure, to give it the precedence to all others, and that is, it is more hard and tenacious; and when once dipped in cold water, whilst intensely hot, it acquires a still greater degree of hardness, and is every way qualified for the most lasting purposes. By being thus able to resist the strongest efforts, it becomes the guardians, as it were, of our houses, and our most faithful trustee. By linking thus inseparably together the materials whereof they are composed, it secures our persons, not only from the injuries of the weather, but from the hands of merciless and violent men. To this metal we are indebted for the greatest part of our utensils which are made use of, not only in navigation, husbandry, and clock-work, but in all the other liberal and mechanic arts. Gold and silver, had we not iron implements to work and fit them for our several purposes, would be in a great measure useless. We are so much indebted to this particular metal, that our daily provisions could not be commodiously dressed, nor would the furniture of our houses, or the tools of our artizans, be of any tolerable service or advantage to them without it. To sum up its superior excellence in a few words: all other metals, indeed, are useful, but this is absolutely necessary, and we can make no tolerable shift without it.

You see, therefore, fair readers, that we can neither look round about us, move one step upon the earth, or dig under our feet, without meeting with a profusion of those treasures, which were lodged there for our convenience and delight. From every thing we see, we are fully convinced of our being the objects of the

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Almighty's compassion and regard, who foresaw all our wants, and used all the indulgent means imaginable to engage us to be diligent and industrious.

The gracious designs of Providence, however, are still more conspicuous in that due proportion which is fixed between the quantity of these metals, and the measure of our wants. Was any one man commissioned to create metals, and to furnish his fellow-creatures with such stores of them as he saw most convenient, in all probability, he would have been more lavish of his gold than his iron; he would have distributed with a frugal hand his baser metals, and have shewn his generosity and munificence in giving us a profusion of that glittering metal, which we are so peculiarly fond of. The all-wise Author of nature has thought fit to take quite different measures. As the principal merit, and superior excellence of gold, in some measure, consists in the scarcity of it, he has distributed it among us with a sparing and frugal hand: and this prudent oeconomy of his, which is so much complained of by the ungrateful, in reality, very much enhances the value of the blessing: for as iron is so universally useful, and a metal so indispensably necessary, he has furnished us with a profusion of it all over the world. Thus we see he is munificent without the least ostentation, and his whole aim is to promote the real interest and happiness of the receiver, and not the vain glory of the donor.

If Providence, therefore, which is so vigilant for our service, has most effectually promoted the welfare of society in general, by such a wise distribution of his various metals, the quantities whereof he has proportioned to our necessities, is it not evident to a demonstration, that an attempt to render those common, which he has thus dealt out with so sparing a hand, would be an actual subversion of that conduct and frugality which he himself has established? however, we may as soon hope to find out a passage to the moon, as the art of making gold.

There have been numbers of kings and princes, as well as professed chemists, in all countries, who have for several ages past been indefatigable in their re-

searches into the profound secret of making gold. Immense sums of money have been expended, and ten thousand times ten thousand experiments have been made, in hopes of finding it at last. The boldest, and most skilful of them all, the Hamburgs themselves, have ingenuously confessed, that all their knowledge, their incessant toils, and extravagant disbursements, have turned to no manner of account.

Was it possible that the mystery could ever be discovered, it is very natural to suppose, that in the course of such an infinite number of experiments, they might casually at least, and by the dint of good fortune, have hit the mark; and yet, after so many treatises written on the subject, so many conferences held, and such numberless efforts made in vain to attain the art of extracting gold, and transforming metals, we daily meet with those who employ themselves in the pursuit of this mighty secret, but never as yet could venture to say boldly, There goes the happy man that has actually found it.

No regular method has ever been produced as yet, that may be depended on; and it is too melancholy a truth, that all our indefatigable projectors in this way ruin themselves in the first place, and then draw in some wealthy dupes, who continue to advance their money so long, in the prosecution of their expensive schemes, till they become as poor as their dependants.

By an intermixture of metallic and other substances, we may be able, indeed, to produce a metal that is different from all others; such, for instance, as bismuth, cast copper, or brass, Prince's metal, and the like, much after the same manner, as by a mixture of water with several good salutary fruits, or by transfusing of various kinds of liquors from one vessel into another, we may produce one that carries an air of novelty along with it; yet as we have no good grounds to expect, that we shall be ever able to make cyder or wine by art without the aid and assistance of apples or grapes, so all attempts to make gold will for ever be, as they hitherto have been, fruitless and ineffectual, till we shall be thoroughly acquainted with the nature and essence of those first principles whereof they are composed: and, after all, should we ever attain to
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that degree of knowledge, yet the true method of uniting such principles would be a secret that would puzzle and confound us.

It is not without some wise design, that the Almighty, who created these metals, and all other objects that are obvious to our view, has thought proper to conceal their essence from us; for, had he given us as perfect an insight into their natures, as he has done into their uses, it would have engaged our thoughts too much, and made us careless and remiss in all other respects. Instead of applying our gold to the uses for which Providence assigned it, we should spend all our time in the making it; and, by our being profuse and lavish of what was before principally regarded for its novelty, we should render it cheap, and of little or no value. In short, it would totally overturn society, and, instead of a blessing, prove the greatest misfortune.

It is most proper for such finite, weak, ignorant beings as we are to be humble and meek, conscious of our ignorance, and jealous of our own judgment, when it attempts to confront, or find out the ways of infinite wisdom: let us remember how few things we know, how many we err in, and how many we are ignorant of. Let us not dare to carry our researches too far: let us be as cautious in enquiring into his handy-works, as we should be of meddling with his attributes. The great Author of nature has not as yet thought it convenient to discover himself to us any other way, than by a profusion of his blessings. He leads us to the knowledge of his divinity, and engages our affections to him, by his boundless munificence. It is agreeable to the intention of the Almighty, and the order of his good Providence, to make us sensible of the inestimable blessings which he confers upon us. If, however, a due sense of such daily benefactions does not lead us to a knowledge of him, who is the fountain from whence they flow, we shall not only be guilty of the most shameful remissness, but of such an act of ingratitude, as is unpardonable. Let us, therefore, finish what we have begun; and, after we have made our strictest enquiries into the works of

nature, let us duly reflect on the principal end for which the beauty, order, and immense treasure of the whole was principally intended: but let us be careful not to extend our enquiries beyond the limits prescribed to human reason.

The survey of nature, therefore, when rightly pursued, is a kind of popular theology, where all mankind, how illiterate soever, may learn those truths, the knowledge whereof is a concern of the utmost importance.

The voluminous treatises, that have been published to prove the existence of a God, of which every one in their right senses must be as fully convinced of as they can be of their own; the numerous sermons and theological lectures, which are founded in some particular countries for the establishment of a truth that is obvious to men of the weakest capacities, are, in our opinion, little better than so many acts of indignity offered to the understandings of those who either read the one or attend to the other: at best, it is all labour lost, since those authors idly imagine, that the world is pestered with a swarm of atheists, when, in reality, there can be no such men in being; or, if there were, they make their application to the reason of such abandoned wretches, as are wilfully blind, and open to no conviction, how plain soever: and, for that very reason alone, are altogether unworthy of such a condescension.

To conclude, if the whole universe be, as doubtless it is, a lively image of the perfection of the Deity, the intention and design of this picture, or representation, is not only to demonstrate to us that he is its author, but to convince us, beyond all contradiction, of his unity, power, wisdom, independence, goodness and providence. It is like an agreeable school, where we may be improved, if we will but open our eyes, and where truth even prevents our researches, by presenting itself so openly to our view, that we cannot but be attracted by her charms.



BOOK V.

Of Vegetables, &c.

CHAP. I.

Of Vegetables in general.

IN every vegetable production, we may consider either the seed, the root, the leaf, the bark, the stalk, the pith, and the flower: all of which are necessary in carrying on the business of vegetation, and transmitting the species from season to season without interruption. But, though the principles of vegetation reside in every part of the plant, yet we generally find greater proportions of oil in the more elaborate and exalted parts of vegetables, namely, the seed. This containing the rudiments of the future vegetables, it was necessary that it should be well stored with principles that would preserve the seed from putrefaction, and tend to promote vegetation. When the seed is sown, in a few days it imbibes so much moisture, as to swell, so that it produces the radicale or incipient root, with some force, which, when shot into the ground, imbibes nourishment from thence, and what it receives becomes, in a short time, the chief supply of future growth. When the root is thus far grown, it supplies the plume with nourishment, till this, by expanding and growing thinner, turns to green leaves, which are of such importance to the incipient

ipient plant, that it perishes, and will not thrive if they are pulled off. But when the plume is so far come to maturity, as to have branches and expanded leaves to draw up nourishment, seminal leaves, being no longer useful, perish, their perspiration being impeded by the newly-produced leaves that overshadow them, and their sap being drawn away by the larger channels of the upper foliage.

As the plant advances in stature, the first, second, third, and fourth order of lateral branches shoot out, each lower order being larger than those immediately above them, not only on account of their having a longer time to grow, but because, being inserted in larger parts of the trunk, and nearer the root, which is the grand supply, they are provided with greater plenty of sap; from whence we frequently see trees tapering beautifully to the top.

Upon the discovery of the circulation of the blood in animals, botanists seemed willing to think, from the analogy there was between all the works of nature, that the same circulation must also have prevailed in vegetables; and some have actually undertaken to prove, that the sap first arises to the tops of trees by the pith, and then again descends to the root by the bark, with the swiftest motion. This was long a received opinion, till the learned Dr. Hales undertook, by experiment, to undeceive the public, and has led many to be of his opinion: when, says he, the sap has first passed through that thick and fine strainer, the bark of the root, (which may be regarded as the stomach of vegetables in general, where the greatest part of the nourishment is prepared and taken in) there it is found in great quantities in the most lax part between the bark and the wood, and early in the spring it begins to rise. But as this sap is imbibed from the earth in great quantities, its celerity, continues he, would be incredible, if that quantity first ascended to the top of the tree, and then descended again before it was carried off by perspiration. The defect of circulation, however, in vegetables, he accounts for by the superior quantity of liquor carried off by perspiration, than what is perspired by animals; having
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shewn that a sun-flower, bulk for bulk, imbibes and perspires seventeen times more fresh liquor than a man, every twenty-four hours. So that though the sap ascends with great velocity in vegetables, from this great quantity of subtil fluid carried off by the leaves, yet there seems no reason for its descent in any such proportion; nor would it have sufficient time to supply the plant with nutrition, if it went round so briskly. Such was the opinion of this great naturalist.

Mr. Du Hamel, however, who has written since his time, has undertaken to prove the descent of the sap in vegetables, as well as its ascent, by making a circular incision on the barks of trees, and finding the swelling of the bark above the incision was greater than that below it, which equally answered if the plant and its pot were inverted, the roots being in air, the branches downwards. However, this may be certain, that there is a constant flow of juices through every plant, the roots furnishing it in great quantities, while the leaves, spreading an extended surface to the sun, have their moisture attracted in very large quantities, and, when the influence of his beams no longer continue, they at night act as sponges, and imbibe the humidity of the air. Thus we see that the leaves are absolutely necessary in the works of vegetation; they, like young animals, are furnished with instruments to suck it from thence: and, besides this, they separate and carry off the redundant watery fluid, which, by being long detained, would turn rancid, and become noxious to the plant.

As the leaves are found to exhale moisture, so they are known to imbibe nourishment from the air. The acid and sulphureous spirit, with which the air abounds, is thence extracted by the leaves of plants, so that it is probable the most exalted and aromatic principles of vegetables are derived from this source, rather than from the grosser watery fluid of the sap. Leaves are found to perform, in some measure, the same office for the support of vegetative life, that the lungs of animals do for the support of animal life; but, as plants have not a power of contracting or dilating the chest, their inspirations will depend wholly on the alternate changes

changes of the air. The vine is known, by experiment, to draw but little watery nutriment from the earth by its roots, and therefore it imbibes greater quantities of dew, impregnated with air by night, from whence it derives its richness of flavour: and this may be the reason, why plants in hot countries abound more with fine aromatic principles, than northern vegetables; the former chiefly extracting their juices from the air by the leaf, the latter theirs from the earth by the root.

Nothing can exceed the regularity with which leaves are placed on every plant: but the care which, when budding, nature seems to take of the young shoots still deserves greater admiration; for the most tender parts are ever defended by those which have acquired a greater degree of strength. Besides this, the leaf, as may be easily seen, has two different surfaces; the upper, which seems more smooth and polished; the lower, in which the ribs are more prominent, and of the colour of a paler green. The cause of this difference has not a little puzzled the botanists of every age; perhaps, the upper polished surface, from its position, being more liable to the external injuries of the air and rains, is thus formed rather to defend the lower part, in which, probably, the attractive powers may reside. In this manner the leaves of trees contribute to improve the flavour of the fruits, and regulate the vegetation.

When the trees stand thick together in woods or groves, the lower branches, being shaded by those of the neighbouring trees, can perspire little, and imbibe less, wherefore they perish; but the top branches, being exposed to a free air, they perspire plentifully, and, by this means drawing the sap to the top, they advance in height rather than extent. Dr. Hales compares a tree to a complicated engine, which hath as many different powers of attraction, as it hath arms or branches, each drawing from their common fountain of life, the root. The younger the plant, the greater its power of attraction; while, as it grows older, the vessels of circulation become more rigid, and the parts to be produced more inflexible, till at last the parts are

no longer capable, from the rigidity of age, either of profusion or dilatation, and the plant acquires its greatest degree of hardness, but continues to vegetate no longer. So that in all we see the admirable contrivance of the Author of nature, in adapting different ways of conveying nourishment to the different circumstances of her productions.

The assiduity of nature in the production of the growing plant, is not greater than her care to preserve the seeds, which are to propagate the future vegetable uninjured. The curious expansion of blossoms and flowers seem to be appointed by nature, not only to protect, but also to convey nourishment to the embryo seed. The fruits, in general serve to supply the seed with moisture, and may be compared to a chemical laboratory, in which the oleaginous juices are prepared: those kernels in particular, which are inclosed within a thick shell, and receive nourishment from the fruit expanded round it, have the vessels, which supply this nut, running perpendicularly inward, but making convolutions round the edges of the shell in order to prepare the oils in still greater perfection.

Though fruits in general are the most inconsiderable agents in promoting the work of vegetation, being, as we have already observed, only destined to supply the seed with proper moisture and nourishment; yet, with respect to man, they make the most useful and pleasing part of vegetable productions. Their general properties, as constituting a part of our food, may be considered as arising from their different degrees of maturity: in general, while unripe, they may be considered as astringent, and in some measure partaking of the qualities of the bark of their respective trees: when come to a sufficient degree of maturity, they cool and attenuate; but, from too great a power in these respects, they often bring on disorders that are fatal, particularly in warmer climates, where their juices are possessed of these qualities still more than with us. In our climates, however, this seldom happens, and they probably do not make a sufficient part of our diet.

As to the increase of plants, some proceed from seeds only, others from seeds or suckers; as tulips, for instance, which have seeds in their pistils, and a large quantity of small suckers, which rise, in a numerous progeny, round the parent plant. Some are augmented, and brought to perfection by scions or grafts, which are no more than small branches of the finest sort, artfully inserted in an aperture made in the wood or bark of some wild or ordinary plant. Others are multiplied by slips. The strawberry plant throws out two long fibres on each side, the knots whereof take root in the earth, and become so many new stems. The branch of a vine bowed down, and thrust into the earth, shoots out fibres through the knots that lie buried and concealed; cut the branch off where it joins with the stock, and the other end, which rises out of the ground, becomes a new vine. In short, there are plants that proceed from little slips or twigs of trees, when set in the ground, without any other manual operation.

There is no difficulty in accounting for the two first, because a seed, or a seed and a sucker, contain in them a shoot, or a minute plant complete. The graft, likewise, containing its buds for leaves, as well as fruits, the sap, when it flows into it, not only gives but discovers what the graft contains. Let us now proceed to what at first sight seems more difficult to be accounted for, the increase from slips of trees. When we set a slip into the ground, the sap, which overflows it, puts some of those shoots in motion, which are to produce new branches. The little suckers, which expand themselves on each side, are, by the pressure of the earth upon them, prevented from rising with ease into the air. The juice which ascends into the stem, coming afterwards to flow back, and descend upon the same suckers in the earth, take their course downwards, instead of upwards, and become roots instead of branches. From whence we may conclude, that the stem gives only a passage to the sap and the air; that the sap and air give nutriment and motion to all the shoots; but that these shoots are produced before-hand, and

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are perhaps wrapped up in one another from the beginning of the world, for the benefit and advantage of mankind through the succession of all ages.

CHAP. II.

Of Flowers.

FLOWERS are formed to please us, and it is for our sakes that they have received their amiable appearances: no eye but ours can enjoy their beauties: the animals never seem to be affected with pleasure when they behold them, nor do they ever stop to consider them with attention: they confound them with the common herbage of the field, they trample on the most beautiful of the tribe, and are perfectly insensible of this ornament of the earth. Whereas man, amidst a croud of objects and riches that surround him, distinguishes and pursues the flowers with a peculiar complaisance.

They have likewise an agreeable correspondence with our eyes, and a set of powerful attractions that invite us to approach them. Whenever we gather them, they present us with new perfections, in proportion to our regarding them with nearer attention. The greatest part of them not only regale our view with the beauty and arrangement of their colours, but gently delight our smell with an exquisite perfume; and, when they have gratified our senses with an innocent satisfaction, the mind still discloses wonders in them, which ravish its faculties.

Were we to trace a flower through all its progress, from its birth, it will always appear in the place where the seeds are to be unfolded; and where that is wanting, these are not to be expected. The trees that grow in forests, and those that bear fruits, the different kinds of pulse, together with the herbage of the field, are yearly covered with flowers, more or less lively in their glow, in order to produce a fruit or seed, which is generally formed, unless the flower itself was in no condition

condition to blow, or has not been sufficiently preserved.

When we have carefully surveyed the structure of a flower, in order to discover its relation with the seed, we always find one or more inclosures appointed for the reception of the seed: around that inclosure is a set of chives sustaining several packets of powder, which they scatter on all parts. The whole is encompassed with an empasement, or soft robe, that unfolds and closes, with a kind of precaution, according to the disposition of the air. All these things convince us, that these parts, which are disposed with so much art and regularity, and wither round the inclosure, when the seed is formed, are instrumental in the generation of that seed. We are likewise convinced of the original design of flowers: the Almighty, by dispensing the verdure of the earth to mankind, has perpetuated his gifts, through all ages, in consequence of the commission he has given the flowers to renew each plant from year to year, by infusing fertility into the seed.

This important and first design to procure immortality to plants, is not inconsistent with a second, which is to delight the view of man. When God created the flowers, he thought fit to blend utility with pleasure. If he had only appointed them to furnish each plant with a re-productive seed, he would not have graced the generality of them with such amiable forms and engaging colours; but they would have resembled roots, which, being only calculated to impart nourishment to the plant in a situation of obscurity, were not provided with any embellishment: whereas that great being, who formed the flowers, seems to have taken pleasure to shape and paint the greatest part of them in such a manner, as qualifies them to regale the view of man, and adorn his habitation.

Let us be more particular in the pleasures they are commissioned to procure us. In the first place, there are a number of flowers that seem only formed to present mankind with a collection of sweets; while others are preparing for him a fruit, which he will use after the disappearance of the flower: these are far from
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being indifferent, though he is not conscious they have any other merit than the pleasure they afford him; but they present themselves to him in their turn, with such an engaging air, as makes it evident they all pay their court to him as their lord.

It is difficult to conceive how far the design to delight man with the beauty and profusion of flowers has been extended. Their multitude is a real prodigy, and one would imagine they had been commanded to spring beneath every step we take. Each part of nature unfolds them to our view in their turns. They rear their heads on the lofty tops of trees, and are diffused through the herbage that creeps along the earth; they embellish the vallies and the mountains, and the meadows are enamelled with their colours; they are gathered from the skirts of woods, and make their appearance even in deserts: the earth is a garden entirely covered with their bloom; and, lest man should be deprived of this delicious prospect, when he retires within the confines of his habitation, they seem desirous to render this more amiable to him, by ranging themselves in his parterre, and creating him more pleasure than they afford him in any other situation.

The beauty of flowers never fails to inspire us with joy; and, when we have sufficiently examined the fairest, we are sensible they are only proper to refresh the sight; and, indeed, the prospect they afford is so touching, and we experience their power to be so effectual, that the generality of those arts, which are ambitious to please, seem most successful when they borrow their assistance. Sculpture imitates them in its softest ornaments, architecture bestows the embellishments of leaves, and festoons on those columns and fronts, which would otherwise be too naked. The richest embroideries are little more than foliage and flowers; the most magnificent silks are almost covered with these charming forms, and are thought beautiful, in proportion as they resemble the lively tinge of natural flowers.

These have always been the symbols or representations of joy: they were formerly the inseparable ornaments of feasts, and are so peculiarly adapted to scenes
of

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of pleasure, that they are always considered as inconsistent with mourning: decency, informed by nature, never admits them into those places, where tears and affliction are predominant.

The festivals in the country are never celebrated without garlands, and the entertainments of the polite are ushered in with flowers: if the winter denies them the gratification, they have recourse to art: a young bride, in all the magnificence of her nuptial array, would imagine she wanted a necessary part of her ornaments, if she did not improve them with a sprig of flowers: a queen, amidst the greatest solemnities, though she is covered with the jewels of the crown, has an inclination to this rural ornament; she is not satisfied with mere grandeur and majesty, but is desirous of assuming an air of softness and gaiety, by the mediation of flowers.

We may, indeed, in some measure, consider it as a misfortune, that we should ever be deprived of the view of beautiful flowers. But, alas! what more is the beauty of our fair readers, than the emblem of a short-lived flower!

*The fairest forms that nature shows,
Sustain the shortest doom:
Beauty is like the morning rose,
That withers in its bloom!*

But let us quit this disagreeable reflection, and return to our subject. As the generality of flowers are employed to adorn our dwellings, at least for a certain time, they never make their appearance in one united body, nor at the same period of time: they tender their service in succession, they agree to beautify the different seasons, they succeed each other without leaving any vacant spaces, and we seldom complain of their absence, since they divide among them the greatest part of the year.

The flowers, by this succession, entertain us with a splendid feast, wrought into decorations that succeed each other in a regular order. The flowery liverwort, cowslips, violets, hyacinths, auriculas, lilies of the valley,

valley, daffodils, and wind-flowers, present us, if we may use the expression, with the first act.

These disappear, for the most part, and resign their places to imperial crowns, Arabian beans, jonquils, the ranunculus, and various other flowers; and, intermixing their softest colours with the distant fruit-trees and rising verdure, heighten the prospect on every side.

We may at the same time see the opening bloom of the rose-bush, the lily, the Julian, the gilliflower, the Mithridate mustard, the carnation and poppy, whose stems and buds are fortified by insensible growth: these are the preparations for the array of summer.

Autumn will afterwards unfold the pyramidal, the balsamine, the turnsole, the tuberose, the amaranth, the Indian pink, and the meadow saffron, with a variety of other species. The scene is continued without interruption: the predominant colours are always assuming an air of novelty, and prevent, by their agreeable variations, that disgust which is inseparable from uniformity.

The winter, attended with its train of frosts and lowering skies, draws her sable curtain at last over the face of nature, and intercepts its features from our view; but, while it disposes us to wish for the return of verdant scenes and flowers, it affords some repose to the earth, which had been exhausted by so many productions.

We are so sensible of the beauty of flowers, that we have acquired the art of securing their presence, in spite of the rigours of winter. We preserve the shattered remains of autumn, and can frequently raise a bloom of spring flowers, without waiting for the return of the zephyrs, whose approaches we always think too slow. The tuberose, the amaranth, the stork-bill, and the whole class of flowers that are well regulated, may be much retarded in their appearance, and preserved till the laurus-tinus flourishes in our apartments, that exclude the injurious blasts of the north. The wind-flowers and the violets, aided by a moderate heat, and the hyacinth and daffodil placed in a warm air, and daily refreshed with water, will adorn our chimnies

chimnies in the most gloomy months. Thus do we connect the autumn and spring, and they seem to associate with a pleasing harmony.

The flowers are not only diversified from one season to another, but even those that bloom together in the same period of time have a beautiful variety of forms, which demonstrate the endless invention of their author, together with his design to multiply the ornaments of our habitations. It is impossible to enumerate the different plans, by which all the families of flowers have been formed, without repeating any perfect similitude between them: every touch is truly original, and peculiar to a certain species: they vary among themselves, in the shape of the petals, and the delicacy of the fringe that borders them, the disposition of the chives that are connected with the heart, the structure of the cap that unites the several parts, the formation of the stem that sustains them, the turn of the green foliage that surrounds them, and principally in the colours, with which they are tingured, and the airs peculiar to their class. Let us take a short survey of the beauty that results from so many splendid tints.

It is not certain, whether flowers derive more advantage from being viewed in conjunction with each other, or from a separate consideration of their beauties. When they are united in a cluster, they form an assortment that diffuses an engaging propriety through the whole: nothing appears indelicate, ill-disposed, or too much contrasted. The concurrence of all these colours produces a harmony extremely varied, and which entirely satisfies the eye. When they are considered in a separate view, each individual discovers its personal merit by a symmetry peculiar to its nature.

If the divine wisdom seems to have had complacency in the distribution of those colours that array the flowers, what a new charm has it imparted to them in their particular airs and forms! We observe some rising with a mien of dignity and grandeur, while others, without the least pomp or ostentation, attract the eye by the regularity of their lineaments. What

an aspect of majesty is visible in the growth of tulips ! how elegant is the symmetry of those pyramids, in which the lilies appear !

The works of our looms have neither the delicacy, nor the lustre of flowers ; but then they have one advantage, of which these are destitute ; they may be changed and diversified by new inventions, whereas flowers are always the same. The charm of variety is what we are solicitous to procure in all our works : we consult it in our habit and furniture, our music, language and building : all our inventions are in a constant fluctuation, and we are never fixed in any one particular : one mode is banished by another, and we are not certain that the best of our performances will be thought agreeable, either for the space of twenty years, or at the distance of as many leagues. We vary the same thing into a thousand shapes ; but, after we have reformed them with the utmost care, we find ourselves as uncertain, and as little advanced in our progress, as we were the first day. The case, however, is very different in the equipage of flowers : the substance, the colour, the shape, are always the same, if we except a few tinctures, whose variations are very inconsiderable, and always pleasing. We are never tempted to alter them by any additions or diminutions ; we should be deprived of all their beauty by that proceeding, and their model is so amiable already, that we are persuaded it needs no reformation. The roses have never changed from the beginning of the world, and they have constantly created pleasure to this moment.

These are beauties, which, without any preparations, or sedulous attention, have attained their perfection, in all the simplicity of structure, and are fixed by the standard of truth : and this may be considered as the very circumstance that occasions the real difference between the beauty, so inseparable from the works of nature, and that which is changeable and transient in the productions of man.

We must not be surprized, if men are limited, un-fertile, and fickle in their inventions : they proceed with uncertain steps, when they would trace out what

is amiable. That matter which they shape into innumerable forms, in order to accommodate themselves with houses, furniture, and habits, is not their own work: they are even unacquainted with its constituent parts; it often frustrates their labours, and is frequently destroyed, or rather disconcerted under their hands: they endeavour to re-adjust it in a more promising form; but, when they have accomplished it to the best of their capacity, it is attended with fresh inconveniencies, and creates them new dissatisfactions.

The contrary of all this is visible in the works of God, and every part of his creation has a determined and persevering beauty. His will regulates all that is amiable: the object which he has once created never varies, and is always pleasing: he makes it evident that he is the master of nature, and that he renders it tractable to his laws. This matter, which conforms to his orders with so much pliancy and obedience, assumes all the shapes with which he pleases to impress it, and is immediately productive of each effect that he ordains: he imprints upon it the most apparent and opposite characters, according to his sovereign pleasure: he moulds the face of a lion, a tiger, or a leopard, into an assemblage of dreadful features and lineaments, that fill the most undaunted hearts with terror: but, when his unerring hand fashions the same into flowers, to delight our view, he frames them in a different manner: he gives them a soft and elegant form, and arrays them with the most delicate attractions, that inspire us with delight the moment we behold them. He confines the terrifying forms of nature to woods and deserts remote from man; but sheds a profusion of flowers and verdure over our fields, our meadows, our gardens, and all the prospects around us. Man, therefore, beholds himself encompassed with objects that are only offered to his view, with an intention to solace himself in his labours, by presenting him with pleasures in every part, that amuse him without corrupting his mind.

Flowers are not only intended to beautify the earth with their shining colours, but the greatest part of them, in order to render the entertainment more exquisite,

quisite, diffuse a fragrance that perfumes all the air around us; and it should seem as if they were solicitous to reserve their odours for the evening and morn, when walking is most agreeable; but their sweets are very faint during the heat of the day, when we visit them the least.

Let us proceed to account for this. The sap is perpetually transpiring through the flowers, in proportion to the sun's warmth. These fine spirits, which are the essence and aromatic parts of the flowers, are easily dispersed through an air rarified by heat, and affect the smell but faintly at that time; but their dissipation is much abated when the air is condensed by the return of night. The action of the sun, by which they are diffused, is too weak, in the morning and evening, to scatter them to any considerable distance, and it is then that the re-union of these spirits affect us with the strongest impressions. The evaporation of these minute particles forms an atmosphere around the flower, which is dissipated or condensed, as the action of the air or sun is more or less intense.

The spirits, which compose the atmosphere of perfumes, must be extremely subtle and delicate, since the day-light alone is sufficient to disperse them through the pores of some particular flowers. We have an instance of this in the crane's bill, which never dispenses the least odour while the day continues, but is exquisitely fragrant in the night.

This is a demonstration, that the spirit of flowers are dispersed in proportion to the sun's action upon them; but we will not confine ourselves to this particular: in the study of natural things, true philosophy is never limited to the contemplation of their mechanism, but extends its curiosity to the benefits they produce. We are easily sensible of the intercourse that appears between the flowers, the air, and the sun-beams; and can we possibly be unacquainted with that goodness which is so attentive to make this correspondence advantageous to man? Providence has not only enamelled his way with flowers, for the entertainment of his view, but has taken care to embalm

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and purify the air he breathes, by shedding the noblest perfumes in his passage. One would imagine that the flowers acquitted themselves of this duty with a conscious punctuality, since they reserve their most sensible and pleasing exhalations for those moments of the evening, when they behold us resorting to their beauties for our recreation after our labours.

Their services are not limited to the sight and smell, for other senses may derive advantages from their ministration. They supply us with pastes to enrich our deserts, and present us with powders to perfume our wardrobes; they afford us delicate syrups, and even remedies to relieve us when we are indisposed; violets, jonquils, and peach-blossoms, roses, jessamines, carnations, and especially orange-flowers, accommodate us with conserves and a variety of confections, together with essences and distilled waters, that continue to us the enjoyment of the odours, and other useful qualities of flowers, when they have long ceased to be in season.

To conclude, even flowers furnish us with instruction, and conduct us, by gentle steps, to the knowledge of the first being, who has condescended to shape and paint them with so much delicacy, and to grace them with such a variety of beauties. How amiable must he then be, who is the source of so many charms in such an infinity of objects, to whom he constantly imparts the same lustre they disclosed when they first appeared on the earth! and, if he has been pleased to bestow so magnificent an array on creatures of such a transient duration, and who to-morrow will be withered and trodden under foot, like the herbage of the field, what will he not do for us, who are the objects of his complacency!

CHAP. III.

The Culture of Flowers.

TO describe the various flowers the earth produces, and the different methods of raising and improving them, would be a tedious task, at least would exceed the compass of a volume itself; we must therefore content ourselves with speaking of those which are most remarkable and worthy our attention, such as the auricula, the anemone, the tulip, the ranunculus, and the carnation.

The auricula has several qualities which entitle it to our esteem: we admire the vivacity of its colours, the variety of its kinds, and the duration of its clusters; and though the finest of the species disappear before the close of spring, yet there are others which preserve an engaging aspect even to the summer season.

The auricula is a native of the Alps, though several believe it to be a product of France, and assure us they have discovered great numbers of its plants in their meadows. They add, that some Flemish merchants, delighted with the lustre and fragrance of these spontaneous flowers, which they observed in their travels, transplanted several of them to Lisse in Flanders, and were very careful of all those productions that were most beautiful. It is not easy to be imagined how much this wild and neglected flower was diversified and rendered perfect by a due cultivation. It returned from Lisse to its own native land, in all the charms of novelty, and met with a favourable reception, not only as it had the air of a foreigner, but because it was amiable in the utmost perfection.

As to the qualities of a fine auricula, we think it most agreeable when it enjoys a strong and substantial stem, and when the number of its bells, which rise on that stem, are large, and diffused into a graceful cluster, without inclining too much to the earth. The flowers should likewise be large, well assued, and regular in

their forms. The leaves of each flower should be very smooth, and their colours of a lively glow. The chives should not shrink to the bottom of the vase, but ought to be disposed around its opening in the form of a little sun. They are very defective, when the pistil becomes visible, and the chives are concealed. The eye, which adorns the bottom of each flower-cup, should be exactly rounded, unless it happens to be wrought into a perfect star, which is not disagreeable; but it ought, in particular, to be large and white, or at least as clear as possible.

The striped auricula was formerly in much greater esteem than at present, they being found by experience to be the least durable: the stripe frequently drinks up all the colour, by enlarging its dimensions from year to year. The unblended colours are now valued, when they are strong and radiant. Those that imitate the gloss of satin and velvet have the first rank allotted to them by the curious. A few irregularities of growth give them an agreeable variety: we may observe some, whose cups rise one above another in two or three stages: but this is rather an imperfect arrangement, than any real beauty.

The auricula is certainly a voracious plant, and must be reared in a strong earth, intermixed with cow-dung, to render it soft and oily; it should likewise have a proportion of horse-dung, or sand, to make it light and pliant. It loves a freshness of air, and cannot long subsist in the sunshine, especially at noon, unless it be in the winter season.

Besides the method of raising it from seed, it may be multiplied by offsets, or, in other words, we may separate and transplant the little shoots that spring from the principal stem. Its root, which is a kind of turnip, may be safely transplanted, when we cannot otherwise disengage from it the little fibres, or roots, that are necessary to each offset. When we have recourse to this operation, great care must be taken of the buds in the main stem, which are the hopes of the succeeding years; and when this stem with its shoots are transplanted, the fibre, which connects the root with the stem, must be always raised above the earth.

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Let us now proceed to the anemones. They are satisfied with a light and sandy soil, enriched with a mixture of compost; and, if they are but sheltered from immoderate heats and colds, they generally thrive in a very agreeable manner.

The beauty of this flower results from the just symmetry of all the parts that compose it. The green leaves that surround it without should be low, thick-set, and finely cut; the stem ought to be strong, in order to sustain the flower, without bending under the weight; the head must be elegantly rounded, and the colours bold and radiant. All faint hues, in general, are rejected. The large leaves that unfold the outward surface of the flower, and are called the robe, should neither be straight nor pointed, but round and spreading. The tufts of small leaves, that cover all the flower within, ought to be formed into a dome, by gently bending towards the heart. The larger these leaves appear, the more graceful they render the flower; but, when they happen to be sharp and narrow, the anemone is disregarded, and degenerates into a thistle. The slender bend at the heart ought to differ in its tincture from these leaves, and should appear but little, or rather not at all, lest it occasion a swelling; and it must never rise higher than the leafy tuft. When any such swelling is created, and if by unfolding itself it discloses either the seeds, or the tops that cover them, the anemone is destroyed; for it then begins to divest itself, from year to year, of its inward leaves, to whose number and substantialness it owes its chief beauty.

When the green leaves that encompass the flower begin to wither, the roots should yearly be raised out of the earth, and transplanted in autumn or February; but, lest any accident should scorch and destroy what was planted before the winter season, it is usual to preserve, in some dry place, a large number of these roots, which ever shoot in the repository, like onions, and are even good when they have been kept two or three years.

We may easily secure an agreeable succession of these flowers, through all the seasons of the year. If we

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plant them in the different months of spring, we shall always have new ones, from the latter end of June to the end of summer; and those we plant in July and August, will continue to embellish the close of autumn, and the very heart of winter.

This flower is said to have been first brought from the East-Indies.

The form of the anemone is more delicate, but the tulip eclipses it by the lustre of its colours; and, in this particular, it may justly be called the queen of flowers.

A tulip may be multiplied either by its seed, or else by its offsets. The seed produces a little coated root, like an onion, which must be replanted at the end of two years, but it never blows till the expiration of five or six. Its production seems, at first, contemptible and indelicate; for it is only a large flower, tinged with grey, a violet blue, or some other faint and gloomy colour, and it rises on a monstrous stem. These colours are afterwards improved in a surprising manner, and gradually unfold a splendid variety. The tulips that spring from seed are called breeders, till they are finely marked with some stripes of a new tincture.

When they have been diseathed, and re-planted for several successive years, the tulips produced from seed begin to break into stripes, and are then generally called chances, because they are beauties, on whose continuance we can never depend with any certainty. A series of years, a thinness of soil, and repeated transplantations, generally change or sully the predominant colour. The stripes, therefore, may be considered not as a distemper, but rather as a kind of weakness imparted to the plant, in proportion as the flow of sap is more or less delicate: and this effect corresponds, in a great measure, with the white and grey that alter the natural colour of our hair, at the approach of old age. There are some heads, on which this change has no unamiable appearance, and it is frequently attended with peculiar graces.

The second method of multiplying tulips is by offsets, which are little coated roots that spring from the large one, and should yearly be separated from it.

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Those plants, whose roots resemble an onion, are commonly perpetuated by offsets of this nature, which may be considered as the younger, or collateral branches of the parent root; and while this exhausts its vigour, and divests itself of all its juices, for the nourishment of the flower, the offset, that is strongest and most advanced, becomes the principal root; and, when we raise it out of the earth, it is customary to disengage it from the others, which, when they are afterwards replanted, will produce flowers the second or third year.

The tulip that springs from seed are most adapted to afford us new productions; but their multiplication by offsets is attended with two considerable advantages: one of which is, that we are never left long in expectation; the other, that we are always sure to be furnished with tulips of the same species with those that produced them.

As to the qualities of a fine tulip, the green tincture was once the subject of various rules; but, at present, its appearance is always thought pleasing, when the tulip is fine in other particulars. The stem is a kind of pillar that supports a vase, and to which it ought to be duly proportioned. It is equally disagreeable, if it either exceeds the proper height, or has not sufficiently attained it; or if it swells to an extreme degree; or else appears too slender, unless that excess of slenderness be considered as its principal defect.

A large flower-cup is always more agreeable than one of a moderate size: the tulip is not allowed the least merit, when it happens to be extremely small, but we disregard it the most when it is either flat or pointed. The leaves should never have an outward slant, nor bend into a dome within, but ought to be expanded with a regular and graceful air. Instead of being formed into a slope, or separated towards the bottom, they should spread with an easy freedom. Their number must be always six, and each of them ought to be substantial and well stiffed, that their bloom may be longer preserved. The chives appear best with a brown cast, because it adds force to the lively

lively colours of the flowers; but it is not material with what hue the pistil is tinged.

Let us now proceed to the ranunculus, which is generally supposed to have been brought to us from Tripoly in Syria, several ages ago, and possibly in the time of the crusades. But it was a very considerable period before any but the double flowers were cultivated. A few years since, some seeds of the semi-double flowers were brought to us from Constantinople, where the fine ranunculus is very common.

This charming flower, in order to present us with the most lovely enamel that ever glowed upon a single species, requires nothing more than to be planted in a rich earth, with a small intermixture of ashes or rotten wood, and to be sheltered from humidity and severe colds.

The carnation is, perhaps, the completest of all flowers, since it wears the finest array of colours, is graced with the most delicate shape, dispenses an aromatic fragrance around it, and is attainable in every season of the year.

The carnation, like the tulip, has its stripes formed in the strongest opposition to the predominant colour, into which they are never softened; but they must likewise be extended, without any interruption, from the bottom of their leaves to their other extremity. The large ones are much finer than the small, as they exceed them in the number of their leaves by one half, or a fourth at least. The noble spread of a carnation forms a circumference of nine or ten inches with a diameter of about three. They are greatly prized when they have a multitude of leaves, because they form a more elegant figure. It is much more graceful when the head is beautifully rounded like a tuft; than when it is only flat. Too great a number of spots would create a confusion in the flower, and were it too much indented, it would seem jagged. When the extremities of the leaves, instead of being properly arched, are lengthened into a point, they make a wretched appearance, and this is the greatest defect it can possibly sustain.

Carnations may be propagated either from seeds or layers. The seed diversifies the species of the flower, and the layer perpetuates those that are most amiable. The layer should be planted in the month of July, and not sooner, lest the flower on the stem should be injured.

Another method of multiplying carnations, and producing those that are beautiful, in a short time, is to separate the layers from the stem of those kinds that please us. The layers frequently contain others, that may be considered as subordinate to them; and we strengthen the parent plant, by relieving her from so numerous an offspring. The principal carnation, no longer sharing the sap with so many competitors, gains greater vigour, and assumes a more agreeable appearance, while the layers are likewise strengthened the sooner, and produce flowers of an equal beauty in a shorter space of time.

When we separate the layers from the main stem, with a slender root to each, we must be careful not to injure them by such wounds, as may be destructive to the parent, and her tender progeny. In all operations, however, there is an art and dexterity of management that results from practice, and can never be acquired by the knowledge of a mere set of rules.

These are the five sorts of flowers, which are the chief amusement of those who are curious in the productions of nature; however, they are not disregarded of the others, but raise such a number as is proportionable to the plot of ground they possess. The hepaticas alone (when those that are blue are properly blended with the red and white) are sufficient to afford a month's embellishment to the verge of a parterre, or a court, when the snows of February are melted. They may be intermixed with cowslips that spring in our meadows, and whose culture affords great variety, and may be rendered very ornamental. The narcissus, the double violet, the double hyacinth, the double and single jonquils, the red and white sow-bread, and even dazies, when they are well chosen, produce agreeable effects, either when they are ranged into se-

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parate families, or intermixed in the same bed. We might add, the stock-gilli-flower, the lily, &c. and, indeed, almost every flower, however lightly and insignificantly custom and taste may have taught us to behold it, afford us an ample field of admiration, and cannot fail to inspire us with the highest esteem and veneration for the great Author of all things, who has created and formed so many things for our use and amusement,



BOOK



BOOK VI.

Of Terrestrial Animals, Birds, Fishes,
and Insects.



CHAP. I.

Of Terrestrial Animals.

IF custom had not dignified the lion with the awful title of *King of the Beasts*, reason would undoubtedly have bestowed it upon the horse: the former has certainly no manner of right to it; he is rather an usurper and a tyrant; for he makes no other use of his prerogative, than either to devour his subjects, or inspire them with horror and amazement. The horse, on the other hand, neither injures his fellow creatures in their persons, nor attempts to invade their properties: he does nothing to render himself the object of hatred or contempt. No bad qualities can be justly ascribed to him; and, in fact, he is possessed of all such as are amiable and praise-worthy. There is no animal whatever so complete, with respect to the symmetry and proportion of its parts, has a more graceful spirit, is more liberal of his services, and more abstemious in his diet. Cast your eyes on all other animals, of what species soever, do you find one that has so beautiful a head, or eyes so sparkling or full of fire? One whose neck is clothed with equal majesty, and whose mane waves in the wind with so much grandeur? One, in short, who has a more stately chest, a finer body, or

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more curious limbs? Whether he be under the direction of his rider, or at his own liberty to range the fields without controul, we observe, in all his attitudes, a noble deportment, and an air which strikes the eye of every beholder, though insensible of all his other perfections, with an agreeable surprise.

His inclinations are still more engaging: he can properly be said to have but one, and that is, to be as servicable as possible to his master. If it is expected he should drag the plough, or carry any burden, how heavy soever, he is always ready and willing. Does the owner propose to ride him? he seems conscious of the honour, and uses his utmost endeavours to please him; at the least signal alters his pace, and either walks, trots, or gallops, as required: neither the length of his journey, the badness of the road, neither hedges nor ditches, nor even the most rapid rivers, discourage him; he flies like a bird over every obstacle that would give a check to his career. Is there any further service expected from him? is it incumbent on him to defend his master, or bear him to an engagement?—he goes on to meet the armed foe, he mocks fear, and is not afraid; the sound of the trumpet and the drum inspire him with fresh ardour, and he turns not back from the sword.

From a short survey of this noble creature, the horse, let us turn to that useful animal, the dog. Of all the accomplishments which a dog is capable of attaining, there is not, doubtless, any one half so considerable, as that inviolable friendship, and undaunted courage, which he shews for his master on all occasions: and it is very plain, that the Deity consigned the dog to man to serve him as a faithful companion, assistant, and protector. The services we receive from dogs are, indeed, as various as their species.

The mastiff and the bull-dog guard our houses in the night, and reserve all their fury and resentment for that season, wherein necessitous vagrants may form their villainous designs against us. The shepherd's dog is qualified to attack the wolf, when he worries his sheep, and to regulate the flock.

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Among the various classes of sporting dogs, the terrier has very short legs, to enable him to bury himself in the grass, or break his way through a quickset-hedge. Nature has bestowed on the greyhound a sharp head and a slender body, in order to cut the air with more ease, and pursue his game with greater expedition; his long thin legs soon stretch over a large tract of ground; he exceeds even the hare in point of swiftness, whose safety therefore principally depends on his doublings and turnings, and other arts of flight. This creature is the reverse of the terrier, not only in his structure, but his daily exercise and employment. The latter is short-sighted; but then he has a fine nose, because he has more occasion for a sure scent than a quick eye, when he lies concealed in the grass, or darts through a bramble-bush. The greyhound, on the contrary, is of little service but in the plain, and has no scent: he never fails, however, of discerning his prey at a distance, and putting off her changes. The setting-dog stops in a moment, and squats as soon as he spies his game, in order to give his master timely notice. There are divers species of them, whose names vary according to their respective qualifications: all of them, however, are equally eager for the sport, and faithful in the due discharge of their several functions.

In short, amongst all these various domestic animals, who are so tractable, and so unavoidably attached to their owner's interest, there is not one, even down to the spaniel and the Dane, but what renders himself, in some degree, amiable by his sprightliness and activity; valuable by his indefatigable industry, and sometimes serviceable by his vigilance, and the timely notice he gives his master of some approaching danger in the night, when all the family perhaps are sleeping. The horse and the dog, in short, are the only two animals, on whose friendship and fidelity we can with safety depend; for which reason the old proverb says, *A man, a horse, and a dog, are never weary of each other's company.*

Let us not, however, continue too long our encomiums on either the horse or the dog, since there
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are other things more immediately necessary for us, such as food and raiment, and for these invaluable presents we stand indebted to the cattle. The flesh of these animals are so succulent, substantial, and perfect, that we abandon the most exquisite dainties to return to them, and are never cloyed with the refreshment they afford us. It is plain the cow, the goat, and the sheep, were consigned to us by Providence for the increase of our substance. We furnish them with a few herbs, and suffer them to range all day at liberty round the fields, to regale themselves on what they can find, and what is but of little or no service to us; and they return home in the evening, to repay the obligation with large overflowing bowls of milk and cream. The cow alone supplies the poor with what they value next to bread, and crowns the tables of the rich with a variety of dainties. The sheep, well satisfied with being clothed in the winter, freely resigns his fleece to us in the summer. In fine, we are indebted not only to the animals before mentioned, but those too, whom we often look upon with an eye of contempt, for an hundred other conveniencies, which we can never receive from such as are untractable, and study to avoid.

These animals are for ever before our eyes, and we may every day discern in their conduct new footsteps of an all-wise and over-ruling Providence. When we reflect upon the dam, we cannot help observing an excessive fondness and indulgence towards her young: though they have no knowledge of any thing, and are incapable of action, yet the affectionate regard of the parent for them makes ample amends, and all their necessities are instantly supplied. When we cast our eyes upon her young, they are new objects of admiration, through all the variety of their progress: they can find the teat, even before they can see; and, without the knowledge that any pressure of it is necessary, they employ their fore-paws by turns, after a very dexterous manner, and thereby express the liquid that sustains them. When the parent and her brood are parted for any time, they hunt after each other, with all the care and concern imaginable; and, when they

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are within hearing, they give mutual notice by such signals as all of them understand. The dam can distinguish the cry of her own offspring from that of a thousand lambs; and the latter knows its mother's bleat from that of a thousand sheep. The drover himself, indeed, frequently mistakes, but the dams and their young ones are never deceived, and a joyful reunion soon succeeds the reciprocal notice which they give of their arrival.

When the lambkin becomes stronger, and capable of seeking his own provision, it is highly requisite that the dam should be released from her parental charge; for which reason she drives him from her, and even treats him with rigour, in case he persists in following her any longer; and the indulgence of the one is of no longer duration than the necessities of the other. When he has thus lost his milk, he is obliged to habituate himself to a coarser diet. He learns to nibble the grass, and chew the cud all night, upon what he had reserved in the day. By degrees he learns to distinguish the seasons. In the long summer days, he rests and chews the cud too; because he may do both without any inconvenience. But in winter, when the days are short, he has no time to lose: he makes as quick dispatch as possible, for fear of deficiency, and completes the digestion, by re-chewing in the night, at his leisure, what he had eaten the preceding day.

We must not, however, be content with what we observe worthy of admiration in these animals alone, we must carry our philosophy still further. Let us regard the field-mouse, who builds with so much art and elegance. Their subterraneous cells have a free communication with each other; each is appropriated to some peculiar use: one is set apart for the reception of her stores, which consist of all sorts of fruit, according to the season, but particularly nuts and ears of corn. These last are laid up in heaps, and will keep longer than any article of her provision besides: others are appropriated to the service of the family, and furnished with little beds of wool and cows-hair. At the extremity of the lodgment there is one general

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magazine that supplies the whole, in the most elegant manner, with all sorts of accommodations.

The porcupine, and the hedge-hog, between whom there is a perfect resemblance, have their respective magazines. The porcupine is covered all over with large pointed quills, some white, and some black. When he is attacked, he bends his head and paws under him, rolls himself up in a globular form, and erects his prickles of quills in such a manner, that dogs, and other animals, are often obliged to decline the combat: such, however, as are resolute, and persist in the assault, most commonly feel the weight of his resentment; for his pointed quills fly off, wound them at a distance, stick fast in their skins, and the more they stir, plunge deeper and deeper; for the point of them being formed like a screw, every motion of the animal that is wounded, rather fixes than helps to draw them out.

The hedge-hog makes another advantage of his pointed quills; he rolls himself over apples, grapes, or any other fruits he can find, under the trees, and conveys them away in the best manner that he can. He eats what takes up too great a part of his store-room as soon as possible, and makes a reserve of nuts to serve him till the close of the summer. As to the winter, he makes no provision for it, as he indulges himself in sleep the greater part of that uncomfortable season.

We shall now proceed to give a particular description of the beaver, with which we shall conclude this chapter. There are two particulars to be observed with respect to this animal; one is, the use that is generally made of its skin, and the others his peculiar art and address in the structure of his lodge-ment.

This animal is about three or four feet long, and twelve or fifteen inches broad. His skin, in the northern parts, is for the most part of a dark or blackish blue, but inclines to red in more temperate climates. He is invested with two sorts of hair, one is long, the other is a soft down; the latter is extremely fine, about an inch in length, well compacted, and serves to keep the

the creature warm; the former preserves its down from all dirt, or other moisture whatsoever.

The long hair of the beaver is stripped from his skin, and the down was formerly manufactured, or worked up into socks, hose, and caps, and sometimes into stuffs; but, as these have been found to harden like felt, they have not been made use of in many places: at present, this down is worked up in nothing but hats and furs. There is one circumstance, which, though almost incredible, is notwithstanding indisputably true, and that is, those beaver skins are most valuable that have been laid upon longest by the savage natives of the country. By their wearing them, the long hair falls off, and the down being well compacted, and made moist by transpiration, is better prepared for milling. But we will proceed to treat of this creature's habitation, and the several implements which he so amazingly makes use of in the erection of his lodgment.

His implements are these three, his teeth, his paws, and his nails. His teeth are very strong; with these he cuts not only the wood with which he builds his lodge, but that too which is his principal sustenance and support. His fore-feet are like those of such other animals as take delight in nibbling their food, and hold it in their paws; as monkeys, rats, and squirrels do. He makes use likewise of his fore-feet in the first place to dig and scratch up the ground, and then to soften and plash, or mould his clay, which is of singular service to him. His hind-feet are supplied with membranes, or large films, between his toes, like those of ducks, swans, and all other water fowl. From whence it is evident, that the great Author of nature has appointed this creature to live as well in the water as on the land. His tail is long, somewhat flat, and covered all over with scales accommodated with muscles, and always duly liquored with oil and fat. This animal, who is from his birth an architect, makes use of his tail as a trough, or hod, to convey away his mortar or clay, and afterwards as a trowel to perform the plaistering. His scales prevent these materials from doing any injury to his tail, by means of their

their coldness or their moisture; and that profusion of oil, which he diffuses all over his skin with his snout, is evidently of singular service in the preservation of his body from any ill effect arising from the water.

These beavers are social creatures; and a whole body of them will sometimes reside together under one roof, unless some violent heats, sudden inundations, the pursuits of hunters, the want of necessary provisions, or a too great increase of their family, oblige them to disperse. In order to erect a commodious dwelling-place for their reception, they make choice of some spot of ground that is well stored with provisions, and washed by some gentle stream, that they may be enabled to form a basin or reservoir of water proper for their bagnio. Their first care is to erect a mole or dike, wherein the water may rise to a level with the first story of their intended habitation.

The materials whereof this mole consists are wood and clay. These beavers cut, with surprising ease, large pieces of wood, some much thicker than one's arm, and about four, five, and six feet in length, and sometimes more, according as the slope of their habitation ascends. They drive one end of these stakes into the ground, at a small distance one from the other, intermingling a few with them that are smaller and more pliant. As the water, however, would find a passage through the intervals or spaces between them, and leave the reservoir dry, they have recourse to a clay, which they know very well where to find, and with which they stop up all the cavities both within and without, so that the water is duly confined. They continue to raise the dike in proportion to the elevation of the water, and the plenty which they have of it. They are conscious, likewise, that the conveyance of their materials by land would not be so easily accomplished as by water, and therefore they take the advantage of its increase, and swim with their mortar on their tails, and their stakes between their teeth, to such places where there is most occasion for them. If their works are, either by the force of the water, or the feet of the hunters, who run over them, in the least damaged, the breach is instantly made up; every
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nook and corner of the habitation is reviewed, and with the utmost diligence and application, perfectly repaired. But, when they find the hunters visit them too often, they work only in the night time, or else abandon their works entirely, and seek out some safer situation.

The dike, or mole, being thus completed, their next care is to erect their several apartments, which are either round or oval, and divided into three stories, one raised above the other: the first below the level of the cansey, which is for the most part full of water; the other two above it. This little fabric is built in a very firm and substantial manner, on the edge of their reservoir, and always in such divisions or apartments as above mentioned; that, in case of the water's increase, they may move up a story higher, and be no ways incommoded. If they find a little island contiguous to their reservoir, they fix their mansion there, which is then more solid, and not so frequently exposed to the overflowing of the water, in which they are not able to continue for any length of time. In case they cannot pitch upon so commodious a situation, they drive piles into the earth, in order to fence and fortify their habitation against the wind, as well as the water. They make two apertures, at the bottom to the stream; one is a passage to their bagnio, which they always keep neat and clean; the other leads to that part of the building, where every thing is conveyed, that will either soil or damage their upper apartments. They have a third opening or door-way much higher, contrived for the prevention of their being shut up and confined, when the frost and snow has closed the apertures of the lower floors. Sometimes they build their houses altogether upon dry land; but then they sink trenches five or six feet deep, in order to descend into the water when they see convenient. They make use of the same materials, and are equally industrious in the erection of their lodges as their dikes. Their walls are perpendicular, and about two feet thick. As their teeth are more serviceable than saws, they cut off all the wood that projects beyond the wall. After this, when they have mixed

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up some clay and dry grass together, they work it into a kind of mortar, with which, by help of their tails, they plaster all their works both within and without.

The inside is vaulted, and is large enough for the reception of eight or ten beavers. In case it rises in an oval figure, it is for the generality about twelve feet long, and eight or ten feet broad. If the number of inhabitants increases to fifteen, twenty, or thirty, the edifice is enlarged in proportion. It is credibly asserted, that four hundred beavers have been discovered to reside in one large mansion-house, divided into a vast number of apartments, which had a free communication with one another.

Some beavers, that are called terriers, reside in caverns dug in a rising ground, either on the bank of a river, or at some small distance from the water. They dig likewise subterraneous trenches, which run from their caverns to the water, and descend from ten to an hundred feet in depth.

These trenches furnish them with recesses, raised one above another, in which they keep themselves perfectly dry, when the water overflows their lower apartments. When they repose themselves to rest, they spread a sufficient quantity of grass upon the floor, which serves them to lie on.

All these works, more especially in the northern parts, are finished in August, or September at farthest, at which time they begin to lay in their stores. During the summer, they are perfect epicures, and regale themselves every day on the choicest fruits and plants the country affords. Their provisions, indeed, in the winter season, consist principally of the wood of the ash, the plane, and some few other trees, which they steep in water, from time to time, in such quantities as are proportioned to the number of inhabitants. They cut down branches from three to ten feet in length. Those of the largest dimensions are conveyed to their magazines by a whole body of beavers, but the smallest by one only: each of them, however, takes a different way, and has his proper walk assigned him, in order that no one labourer should hinder another.

ther in the prosecution of his work. Their wood-yards are larger or smaller, in proportion to the number in family; and, according to the observations of some curious naturalists, the usual stock of timber, for the accommodation of ten beavers, consists of about thirty feet in a square surface, and ten in depth. These logs are not thrown up in one continued pile, but laid one across the other, with intervals or small spaces between them, in order to take out, with greater facility, just such a quantity as they shall want for their immediate consumption, and those parcels only which lie at the bottom in the water, and have been duly steeped. This timber is cut again into small particles, and conveyed to one of their largest lodges, where the whole family meet, to crunch their respective dividends, which are made impartially, in even and equal portions. Sometimes they traverse the woods, and regale their young with a more novel and elegant entertainment.

Such as are used to hunt these animals, know perfectly well, that green wood is much more acceptable to them than that which is old and dry; for which reason they plant a considerable quantity of it round their lodgments; and, as they come out to partake of it, they either catch them in snares, or take them by surprise. In the winter, when the frosts are very severe, they sometimes break a large hole in the ice, and, when the beavers resort thither for the benefit of a little fresh air, they either kill them with their hatchets, or cover the opening with a large substantial net. After this, they undermine and subvert the whole fabric; whereupon the beavers, in hopes to make their escape in their usual way, fly with the utmost precipitation to the water, and, plunging into the aperture, fall directly into the net, and are inevitably taken. We cannot help thinking, that we now hear our fair readers complaining, out of that tender pity which is peculiar to their sex, that mankind should thus at once cruelly demolish a whole family of these poor creatures, especially since they are such excellent architects, and such shining examples of unwearied diligence.

To conclude, the civet-cat, which is an American animal, and something larger than our European cats, is nothing more, as we are credibly informed, than one of these beavers in miniature; and as their inclinations, it seems, as well as their labours, are much the same, it would be needless to expatiate on that subject.

CHAP. II

Of Birds.

THE whole universe is full of life: each individual of nature is replenished with action, and has its animals peculiar to itself. We can scarce move a step without discerning some foot-steps of wisdom, which is as inexhaustible in its various plans, as it is rich and fertile in the execution of them. Though nothing is more natural to the eye of one who has been accustomed to the sight of a flight of birds, yet nothing is more amazing to the eye of reason. A bird, when on the wing, is a mass raised high above the earth, notwithstanding the gravity of the air, and the natural tendency of all bodies to the centre. This mass is conveyed to distant parts, not by any foreign force, but by a movement peculiarly adapted to the nature of the bird, and which supports her in the air for a long time with grace and vigour. This is a new subject of admiration. When we take these birds into our consideration, we find that nature has bestowed but two wings on any species of them whatsoever, though each individual has something peculiar in the manner of its flight. Some advance by reiterated springs and bounds; others glide along, and cut the air in a smooth, easy, progressive motion: these skim only over the surface of the earth, while those mount fearless, and almost reach the clouds. Some, again, are expert in the variation of their flight, know how to soar in a direct, oblique, or spiral line; to hover without any visible motion of their wings, in an element

ment much lighter than themselves; after this, to launch out in a moment to the right or to the left, then to dart back again, to re-ascend, and at last to drop perpendicularly down like a falling stone. In short, they transport themselves, without the least danger or molestation, to what place soever their necessity or pleasure invites them. When we reflect on them in their little apartments, we find them still the just objects of their admiration: we are charmed with the structure of their nests, the tender regard which they shew for their eggs, and the birth and culture of their young.

It is a very agreeable amusement to observe the resemblance, which is apparent in all the nests of such birds as are of the same species, the difference there is in those of another, and, in short, the industry, neatness, and prudent precaution which are conspicuous through the whole. Their nests are composed of splinters of dry wood, the bark of trees, dry leaves, hay, straw, moss, cow-hair, horse-hair, down, wool, spiders-webs, feathers, and a thousand other materials of the like nature. One species of birds build their nests at the tops of trees, another on the ground and in the grass: but wherever their apartments are situated, they take particular care to have them under some commodious shelter; that is to say, either under some herb, some shady bough, or a double canopy of leaves, from whence the rain may descend, without ever dripping into the nest that lies concealed beneath it. The out-works, or foundation of the nest, consist of more solid and substantial materials; thorns, reeds, straw, and the thickest moss they can get, are made use of for that purpose. On this first layer, in the disposition whereof there is no visible regularity or beauty, they spread and fold, in an orbicular form, a sufficient quantity of their most curious materials, which, being worked up very close and compact, secure the aperture of it from the bleak winds, and the access of any insects: but each species has a peculiar taste in the erection of his lodgment. When the outside is finished, they take all imaginable care to embellish the inside with feather hangings, or to line it
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with wool, in order to make it warm and commodious for the reception of themselves and their little brood. When they cannot furnish themselves with such materials, they spare no pains to find out something that will answer the same end. A lady, who had a very curious aviary, having provided her little guests with nothing more than hay for the erection of their nests, was very agreeably surprised at the expedient the female had recourse to, in order to supply the want of wool or cotton: the little animal set herself to work, and picked feather after feather from the breast of the male, without the least opposition on his side; and with the down she had thus robbed him of, hung her whole apartment in a very elegant and artful manner.— May we not here ask, who informed the female, that she should deposit her eggs there, and that those eggs would be lost without a proper degree of heat? Is it not an infinite wisdom, which directs that bird in her daily labours till her nest is completed? Who acquainted her, that a nest was absolutely necessary to preserve them from falling, and to bring them to perfection by a genial heat; that such heat would not meet in one centre, was a nest too extensive, and that all her young ones would not have house-room, was it more narrow and contracted? By what means is she informed of its due proportion and extent, and the exact number of her future progeny? Who has regulated her calendar, that she might calculate her time aright, and not lay her eggs till her nest was finished, and ready for the reception of them?

But, to proceed, though the bird has no other implement to work with than her bill, and no judgment to direct her, yet still there are such marks of art and contrivance in her works, as discover all the regularity of the basket-maker, and the industry and application of the mason: for, in the structure of some of these nests, we see the down, the hairs, and the reeds are most beautifully interwoven. There are other birds-nests, (says Derham) the respective parts whereof are artfully united and connected by a thread, which is sometimes formed by the birds with cow-hairs and hemp, but for the generality with spider's webs, which

which are procured by her without the least difficulty, when these roving insects sally out, and fill the fields with their threads, by virtue whereof they transport themselves from one place to another, in hopes to find out some suitable companions. There are other birds, (says Willoughby) such as the black-bird, and the lap-wing, or the pewee, who, after they have built their nest, spread a small layer of mortar over the inside, which glews and sustains whatever lies below, and, by the help of a little cow-hair or moss, wherewith it is tempered when fresh made, they erect a perfect wall within—rather let us call it an habitation handsomely furnished, and admirably well calculated to preserve the heat required.

The swallow makes use of no wood, no hay, or bandage; she knows how to plash or beat a kind of parget, or rather cement, wherewith she erects, both for herself and young, a commodious, tight, and decent apartment: she has no pail to hold her water, no wheel-barrow to carry off her sand, or shovel to mix her mortar: she flies backwards and forwards, expands her wings, and wets her breast in the surface of some neighbouring water; then she shakes the dew off upon the dust, tempers them well together, and at last works them up with her bill.

After the completion of the nest, the female deposits her eggs there, the number whereof varies according to the species: some lay but two at a time, others four or five, and some again seventeen or eighteen. The eggs being thus deposited, the dam and male sit upon them alternately; but, for the generality, that office is the peculiar province of the former. And here it is impossible, that any one should be so incurious, as not to discern with admiration that powerful impulse of a superior reason, which acts upon these little animals. They have, doubtless, no manner of idea of the matter contained in their eggs, nor the necessity there is for their brooding over them, in order to hatch them, nor of the manner in which the whole is actually performed: and yet this active, wandering, restless little creature forgets at once her natural inclination, and hovers over those eggs as

long as is convenient and necessary. The dam puts herself out of her bias, bids adieu to all manner of pleasure, and never sits for twenty days successively from her brood; and, in short, carries her paternal tenderness and affection for them so far, as to neglect her very food. The male, on the other hand, bears a part, and alleviates the toil she undergoes: he brings his faithful partner the best provision he can procure for her; he is indefatigable, and travels backwards and forwards without intermission; in a word, he waits on her every now and then with some delicious morsel, ready dressed for her in his bill: his service is attended with all the complaisance and courtesy imaginable. If he discontinues his care and concern for her, it is to entertain her with melodious notes; and he acts with so much vivacity and cheerfulness, with such an air and grace, when he either takes his leave, or makes his approach towards her, that we are at a loss to determine, whether the incessant vigilance of the little mother, or the officious restlessness of her mate, are the justest objects of our admiration.

Let us now proceed to give some account of what is contained within the egg, as well as the manner in which the young one is formed, and how it afterwards breaks through its confinement.

We may form an adequate idea of the egg of the smallest bird that flies, by that of a hen, where the parts are more large and conspicuous. We may easily distinguish the yolk, which lies in the heart of it, the first white substance that encompasses the yolk, and a second white substance wherein the mass swims in the middle: we can likewise discern the ligaments which support the yolk towards the centre of the egg, and the various membranes that invest it, one whereof wraps up the yolk, another the first white substance before mentioned, a third and fourth surround the whole; and, in the last place, we observe the shell, which secures and preserves all the rest. The internal parts are formed first, the shell last, which hardens by slow degrees. It is an effusion of a considerable quantity of salts, which flow from the humours of the female, and which the heat fixes, and consolidates all round the egg for the formation of

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the mother to deposite the egg without crushing it to pieces, the other to defend it from all accidents, till it is duly formed, and strong enough to break through its confinement. It may be said, that the egg is by nature assigned to perform the function of a teat with milk, that nourishes and sustains the young of other animals, because the chick, enclosed within the egg, like a nymph that lies concealed under the skin of a small worm, is nourished at first by the white substance of the egg, and afterwards by the yolk, when the little animal has gathered some strength, and its parts begin to knit. It is under this membrane, which thus encompasses the yolk, that the little speck or white spot is formed, which is nothing more than the semina, or point, in which the chick is enclosed. There is a vital principle infused into those eggs, which have that speck or spot lodged in them. Such, however, as are laid by the hen, without any intercourse or acquaintance with the male, contain in them an unprolific nourishment only, which will never become living creatures. The chick, under its form of a little worm, always presses forward to the yolk, and when there, ascends immediately to the top of that side to which the genial warmth of the dam attracts it. However, since the young might be immediately destroyed by the removal of the egg, and the loss consequent thereupon of that degree of heat which is requisite to support it, the yolk is sustained by two ligaments, which we always find at the opening of the egg, and which fasten it on both sides to the common membrane that is glued to the shell. Were we to draw a line from one ligament to the other, such line would not pass directly through the middle of the yolk, but above the centre, and cut the yolk into two unequal parts; so that the lesser part, wherein the semina is contained, is of necessity raised towards the belly of the bird that hatches the egg, and the other part, being more gross and ponderous, always descends as low as the bands will permit it. Though the egg, therefore, be removed, the young sustains no hurt or prejudice therefrom, but enjoys, let what will happen, such an enlivening warmth, as puts all in action that

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surrounds it, and by slow degrees accomplishes the disengagement of the parts. As it cannot slide down any lower, it supports itself at first in perfect ease, with that delicate, liquid white, which is suitable to its tender nature; but some short time afterwards it subsists on the yolk, which is a more solid and substantial aliment. When its bill begins to harden, and the little animal grows restless and uneasy in its too narrow situation, it uses its utmost efforts to break down its prison-walls, and by repeated essays, at last procures its enlargement. At its first sally, it is fully replenished with the yolk, which is still its principal nourishment and support, till it has strength to stand upon its legs, to go from place to place to seek for provisions, or till its parents themselves come to supply its necessities.

Such birds as are obliged to nourish and tend their young after they are hatched, have very seldom a numerous progeny; whereas, on the contrary, those birds whose young will take care of themselves as soon as disengaged from their shells, have sometimes eighteen or twenty in a brood. Of this last species are quails, pheasants, partridges, and hens.

We cannot here help observing one instance of the goodness and bounty of our Maker, wherein we ourselves are personally concerned: such birds as are either destructive to us, or for which we have little or no occasion, are those which encrease and multiply the least. On the other hand, those whose flesh is most wholesome, and whose eggs are most nutritious, are exceedingly prolific. The hen alone is a little treasure for a man: there is scarcely a day passes but she makes him a valuable present. If, as sometimes it happens, she ceases to furnish her master's table, it is with no other view than to stock his court-yard with new inhabitants: for all which repeated services she requires no other gratuity or acknowledgment, than the fragments of his table, and the refuse of his barn. It would be an act of the highest ingratitude, to be insensible of the value and importance of so generous a domestic. Let us drop this head, however, and return to our birds.

We will suppose the eggs hatched, and the young ones disengaged from their confinement. What a load of cares are the poor parents charged with, till their little offspring are capable of shifting without their assistance! till then they feel the weight of a family: many they find must be provided for instead of two. The linnæ and nightingale are then as industrious and careful as the rest. Adieu to music! they have then no time to spare or spend in singing, at least they very seldom indulge themselves in it at that season. Their necessities are then very urgent; they are indefatigable in their pursuit after provisions: now the male, then the female, and sometimes both fall out together. They rise before the sun; they distribute what they get with the utmost impartiality; each has an equal portion in its turn. This fondness of the dams towards their tender offspring has such an influence over them; that it even changes their natural disposition: new duties create new inclinations: it is not enough to find provision for them, but they must have a watchful eye over them, must defend and protect them, study what is most for their interest and advantage, make head against all such enemies as attempt to invade them, and run the hazard of their lives for their sakes, when drove to the extremity of an engagement. Observe the conduct of a hen with a brood of chickens round about her, and you will find her a new creature. Her tenderness and affection for them alter her very nature, and correct her imperfections: before she was voracious and insatiable, but now abstemious and frugal. If she casts her eyes on a grain of corn, a crumb of bread, or any thing, though never so inconsiderable, that is capable of division, she will not touch the least portion of it, but gives her numerous train immediate notice of her success, by a peculiar call which they all understand: they flock in an instant round about her, and the whole treasure is appropriated to their service. As for her own part, she is very incurious, and contented with any thing she can pick up. This indulgent parent of theirs, though by nature timorous, and apt to fly from the least animal whatever, when marching at the head of her little troop, is a perfect heroine.

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is fearless of all danger, and will fly in the face of the fiercest mastiff.

It is very observable, that a Turkey-hen, when at the head of her brood, will sometimes send forth the most hideous screams, though what should be the real cause or design of her doing so is at that time unknown. However, her young, immediately upon it, fowl under the bushes, the grass, or whatever else offers, for shelter and protection: they vanish as it were in a moment; and, in case their retreat is not, as they imagine, sufficiently safe and secure, they will stretch themselves at their full length upon the ground, and lie for a quarter of an hour, and sometimes longer, motionless, as if they were dead. In the mean time, the mother directs her eyes upwards with an air of horror and confusion: she redoubles her sighs and screams in the same frightful manner as before. Such as are curious, and observe the perplexity and solicitous attention of this mother, cast their eyes up into the air, to find out, if possible, the cause of her inquiries; and, by looking attentively, discover a black spot just under the clouds, but are unable at first to determine what it is. This is a bird of prey, which, although at too great a distance to be immediately distinguished by human sight, cannot escape the vigilance or penetrating eye of this indulgent parent: it is this that creates her fears, and puts her whole tribe in such an agony. Who could inform this mother of an approaching enemy that had never injured her, and hitherto had shewn no act of hostility in the country? Which way could she discover this unknown bird of prey at such a prodigious distance? What private instructions had she given her young family, that they could so readily distinguish, as occasion required, between the intention of one cry and the other, and to regulate their conduct by her language? — But let us turn our reflections on the structure and flight of birds.

The body of a bird is neither very massive, nor equally thick and solid in all its parts, but well disposed for flight, sharp before, and increasing gradually till it has acquired its full bulk or dimension.

E. M.

Thus

Thus formed, the animal is much better qualified to wing away, and steer his course through the regions of the air.

That it may be the better enabled to take a long tour, in which passage such provisions as might be agreeable cannot always be procured, and to qualify it for spending the long tedious winter nights without the least refreshment, nature has furnished it with a bag, which is generally called its crop, just under its throat, and in this magazine he lays up a stock of provisions. The fluid, wherein its meat swims, is a great help to its first digestion. The gizzard, into which but a small quantity of the nutriment enters at one time, performs the rest, and frequently, by the assistance of some little rugged stones, which the bird swallows, in order the better to break such nutriment into pieces, and perhaps to keep the passages more free and open.

Though the bones of birds are solid and substantial enough to sustain and keep their bodies together, yet they are notwithstanding so small and hollow, that they make no considerable addition to the weight of their flesh.

The distribution of the whole plumage is extremely artful, and serves not only to support the bird, but to secure and defend it from the injuries of the weather. Though the quills of its feathers are firm, yet they are very light. By the firmness of them it is enabled to cut the air with a proper force, and by their lightness, in proportion to their growth, it can rise at pleasure, whereas otherwise it would have whelmed it downwards. In short, this hollow quill takes up a large surface, and yet its gravity is inconsiderable, which puts the bird almost in equilibrium with the air. The feathers behind are inverted, and disposed one over another, in the exactest order that could be imagined. That part of them, which is nearest the body, is furnished with a soft and warm down, and that next the air with a double row of beards, something longer at one end than the other: these beards are a range of little, thin, flat plates, disposed in as direct a line, as if their two extremities had been cut with a pair of

scissars. Each of these plates is itself a quill, or basis, that supports two other rows of plates, which are almost imperceptible, by reason of their minuteness, and stop up perfectly close all the little intervals or crannies, through which the air might find a passage. Besides, the feathers are so ranged, that the row of little beards of the one glides, plays, and discovers itself more or less, under the large beards of the feathers that lie over it. A new range of lesser feathers serve as a covering to the quills of the larger. As therefore the air has no influence over any part whatever, the impulse of the feathers on that fluid becomes very strong and efficacious.

But as this economy, so absolutely necessary, might frequently be obstructed by impetuous rains, the Great Author of nature has provided an expedient for them, whereby their feathers are as impenetrable to the waters, as by their structure they are to the air. All birds in general have a bag replenished with oil, which in shape is like a dug or teat, and is situated at the extremity of their bodies. The teat has divers little orifices; and when the bird perceives her feathers to be dry, dirty, wide-gaping, or likely to be wet, she squeezes this teat with her bill, and strains from thence an oil, or viscous humour, which is reserved in the glands. After this, having drawn her bill successively over the greatest part of her feathers, she oils and dresses them, gives them a lustre, and fills up all the vacancies with this slimy matter. When she has thus done, the water rolls off her back, and finds all the avenues to her body absolutely closed.

If there is such wisdom displayed in the structure of the feathers, there is as much beauty in the play of the wings and tail, by virtue whereof it traverses the air with pleasure. Nothing could possibly be more artfully placed than the wings are; they form two levers on each side, which keep the body in an equilibrium. At the same time they perform the office of oars, which, by pressing hard on the element that resists them, cause the body to advance in an opposite direction.

Mr. Willoughby, Mr. Ray, and many others, imagine the principal use of the tail to be to steer and turn the body in the air, as a rudder; but Borelli has put it beyond all doubt, that this is the least use of it, and that it is chiefly to assist the bird in its ascents and descents in the air, and to obviate the vacillations of the body and wings: for, as to turning to this or that side, it is performed by the wings and inclination of the body, and but very little by the help of the tail.

From this general survey of birds, let us turn our attention to more particular enquiries. In the various species of animals, the beaks, the claws, the extent of their wings, and, in short, each individual part of their bodies, is, for the generality, adapted to their several necessities. These are, as it were, so many utensils appropriated to the nature of their work, and the manner in which they live: as, for instance, the sparrow, and most other birds of the smaller size, are principally sustained by the little grains, which they either pick up in our houses or the fields: they have no efforts to make, either for the procurement of their food, or for the breaking it in pieces; for which reason, though the dimension of their beaks, neck, and feet, are but very small, yet they fully answer the end for which they were designed. The case, however, is widely different in regard to the woodcock, the snipe, and divers other birds, who seek for their subsistence either in the deep, in the earth, or in the mud, from whence they extract such little shell-fish and worms as are their favourite food. Nature has furnished these animals with a longer neck and bill than ordinary, whereby they are enabled to dig deep into the ground, or to rake to the bottom of shallow waters, for their food.

The wood-pecker, who lives after a quite different manner, is for that reason of a quite different form: his bill is of a very considerable length, and very solid and substantial: his tongue is as sharp as a horn: it is fortified likewise with several little points, and always covered over with a kind of glew towards the extremity: the legs of it are very short. It has two talons

before, and two behind, all of them bearded like hooks. All this furniture corresponds with the manner in which it lives, and secures its prey. It principally subsists on worms, or such other insects as reside in the heart of particular boughs, but for the most part in the bark of rotten wood. Nothing is more common than to find numbers of these reptiles lodged deep under the bark of our large billets. The woodpecker could never be able to grasp the branches to which he fastens, was he not furnished with hooked claws. Long legs would be of no service to him in obtaining what he seeks for under the bark. A sharp, strong bill, however, is indisputably necessary, because he is obliged, by pecking from one place to another along the branches, to find such places out as are rotten and decayed. If the branch sounds hollow, he proceeds no further, but breaks in shivers both the bark and the wood with his beak. After this he darts it into the cavity he has made, and then sends forth a loud cry, or rather whistle, into the hole of the tree, in order to disperse the numerous insects that lie dormant there, and to put them in a hurry and a consternation. When he has so done, he darts his tongue into the orifice he has made, and by virtue of those little sharp points with which it is furnished, and the viscons matter with which it is plastered over, he drags out all the minute reptiles which he finds, and regales on the booty.

The heron, who is just the reverse of the woodpecker, is mounted a considerable height: his legs and thighs are very long, and scarce a feather is to be seen upon them: his neck and beak likewise are of an immoderate length, and the latter very sharp and indented at the end. Now, can any reason be assigned for a figure, which, at first view, appears so very awkward and grotesque? Yes, a substantial one, and that is, this bird subsists on frogs, little shell-fish, or such other fish as he can find in those marshy grounds which are situate near the banks of large rivers, or the sea-shore. Of what service would feathers on his legs or thighs be to him, in order to wade through the water or dirt? Long legs, however, are absolutely necessary, since

Since they enable him to run along the shores, where the fish resort in shoals, in quest of their daily food. By the help of his long neck and bill he can pursue and snap up his prey at a considerable distance. The indenture and beards of his beak are of singular service to him in securing such fish as he lays hold of, which would otherwise make their escape, and glide from him. In short, his large wings, though at first view they may seem no small incumbrance to his little body, yet they are of singular service to him in making a speedy passage through the air, and carrying ponderous burdens, even the largest eels, to his nest, which sometimes lie a league or two distant from the spot where he fishes. What we have advanced with respect to the heron, is applicable likewise to several other species that resemble him.

The humming bird is to be met with in no country but America, and may be looked upon as one of nature's master-pieces, not only on account of its beauty, but of its manner of life, and the minuteness of its parts. Though the dimensions of it are exceeding small, yet the plumage of it strikes the eye in the most agreeable manner, and glows with all the colours of the rainbow. His neck is dyed with such a blushing red, that it is frequently mistaken for a ruby. The belly, and the down beneath the wings, are as yellow as gold, and its green thighs surpass the emerald. Its feet and bill have as fine a gloss, and are as black as ebony. Its eyes appear like two oval diamonds, resembling in colour the most polished steel; and its head is a lively green, with an intermixture of gold, the lustre whereof is beyond expression. The males have a little tuft or tossel on their heads, in which all the beauteous colours that shine so conspicuous throughout the whole, are assembled and centered. These birds fly with such a velocity, that one may more properly be said to hear than see them. Their principal sustenance is, as we are informed, the dews and juices of the most fragrant flowers. These they extract with their little tongues, which are much longer than their bills. This little instrument performs the office of a trunk, which they contract at pleasure, and infold within

their beaks, as in a case or scabbard. This beak, though no larger than a fine needle, renders them formidable even to the large birds there, called grosbeaks, who make it their business to devour the young of the humming-bird in their nest: if, however, their dam, who is a little heroine, happens to spy one of these cowardly invaders, he flies before her, and tries with all his might, as dreading to feel the weight of her just resentment: the humming-bird closely pursues him, and, if she once overtakes him, lays fast hold of him with her little talons under his wings, and wounds him with her pointed beak. Several of these birds have been brought from Mexico, properly dried, in which state they for some years preserve some part of their variegated colours.

The ostrich is one of the largest birds that nature ever produced: there are more of them in Africa, than in all parts of the world besides. Her head, when in its natural situation, rises as high, and sometimes higher, than a man on horseback. Her head and back resemble those of a duck: her neck, though indeed considerably longer, is something like a swan's. As to the make of her body, it bears some resemblance to that of a camel's, having, like him, a large protuberance, or rising, on her back. Her wings are exceeding strong, but too short for flight, and of no other service to her, than as sails or oars, to enable her to cut and impel the air, which, however, when she runs, adds an exceeding velocity to her motion. Her legs and thighs are somewhat like those of the Heron, allowing for the vast disproportion between them, in respect to size. Her feet rest upon three claws, armed with sharp horns, to render her march more easy and expeditious.

Her eggs are about the bigness of an infant's head. The shell has veins, like marble, and is beautifully polished. The ostrich, like a weak, thoughtless creature, buries them in the sand, and leaves the care of hatching them, as we are informed, to the genial heat of the sun. In all countries where this animal is known, when any one would describe a parent, who shews no thought of, or indulgence towards her

her children, the ostrich is introduced by way of allusion.

There is another instance to be produced, which will sufficiently demonstrate the want of discernment in this bird: when she is pursued by any sportsman, she flies to hide her head, but more particularly her eyes, behind a tree. Though her whole body is exposed to open view, yet, as she sees no one in pursuit after her, that is sufficient, and she foolishly imagines that she is then out of all danger.

They swallow down bits of iron, or other hard matters, not with a view to receive any sustenance from them, but to bruise and grind down the food they have before eaten; to mitigate the excessive heat of their stomachs, and by their weight to open a way or passage into the intestines.

Before we have done with the ostrich, as we have given her but a slender character hitherto, let us do her justice, and say what little we can in her favour: she presents us with the most lovely feathers, both large and long, some white and others black: they are used as ornaments to childrens caps, and were formerly much worn by officers in their hats, and by ladies as fans in their hands. They are of singular service in all our theaters: the heroes there would lose a considerable part, not only of their height, but of their majesty and grandeur, were they deprived of the ostriches feathers.

Of all the various species of birds, we generally look upon those as the most agreeable companions, who are most harmonious, or can prattle most. However entertaining such may prove, they are notwithstanding only foils to the nightingale, whose single voice is more ravishing than the whole choir besides. What can be a more agreeable novelty, than to hear the nightingale in the evening begin to tune her solitary strains, and continue till the night is far advanced? One would imagine, that he was conscious of his own natural perfections, and that it was out of complaisance to us, as well as to gratify his own inclinations, that he condescends to sing when all his fellow-choiristers are silent. Nothing animates him so much,

to find all nature hush and still around him: it is then he composes, and puts all his melody in execution: he wanders from solemn notes to such as are more sprightly, from a smooth, easy air, to the wildest notes that can possibly be conceived, from the sprightliest quavers and divisions, to the softest and most melancholy strains. We at first imagine, that nature has furnished him with an open breast and indefatigable organs, to enable him to sustain such strong and graceful sounds without intermissions, such infinite and just proportions, such a vast compass of music; and yet at last we find it all proceeds from the throat of a very little bird, who, without instruction, study, or the least preparation, performs all these stupendous operations.

As the nightingale thus ravishes the ear, the peacock, with equal wonder, strikes the eye. It is true, indeed, that the cock, the wild-duck, the halcyon, or king's-fisher, the gold-finch, the parrot, the pheasant, and several other birds, are very agreeably arrayed, and that it is a pleasure to reflect on the graces and elegance of their dress: at the first appearance, however, of the peacock, every eye is fixed with admiration upon him: the air of his head, the delicacy of his shape, the variety of colours which glow all over his body, the star-eyes, the light and shadow of his tail, the gold and azure that shine conspicuous in every part, the expansion of his plumage, which he performs with all the pomp and pride imaginable; the majesty of his aspect, and the very care and concern which he visibly shews in the display of all his gaudy equipage to the eyes of his numerous spectators, have a peculiar and astonishing effect. This bird alone is a glorious sight: Could any one imagine now that this bird, thus profusely equipped, could in any respect be disagreeable and give disgust? This, however, is the hard fate of the peacock: he entertains his visitors after the most indifferent manner: he can neither prattle nor sing: his language is shocking and hideous to the ear: whereas the thistle-finch, the linnet, and the paroquet, without any of the peacock's glaring advantages, live with us years together, and never give

give us one moment's uneasiness: they are animals that are unaffected, have more wisdom, and are better bred; and a modest deportment is above all: a gay outside shew, without any other qualifications to recommend it, contributes but very little towards rendering society either agreeable, or of any long duration.

Let us now proceed to say something of birds of passage. There are some kinds of birds of passage, which make choice of the coldest countries; others delight in more temperate climates, and a third species are best pleased to reside in those parts where the sun has the most powerful influence. Some content themselves with passing only from one country to another, to which either the air, or the plenty of provisions, attracts them at some particular seasons. Others traverse the ocean, and undertake such long voyages, as one would imagine morally impossible to be performed by such little creatures. The birds of this species, which are best known, are quails, swallows, wild ducks, plovers, woodcocks, and cranes. There are several other species, however, whose respective names are too tedious here to repeat.

Quails, in the spring, transport themselves from Africa into Europe, in order to reside, during the summer season, in a more temperate climate, than that from whence they came. At the latter end of autumn, they steer their course back again over the Mediterranean, that they may enjoy, in Egypt and Barbary, the same degree of heat, which they obtained in those climates they last abandoned, when the sun was on the other side the equator. These quails take their flight in such numerous troops, that they sometimes appear like thick clouds in the sky, and very often our ships are so covered with them, that the sailors can catch them with all the ease imaginable.

The method observed by the swallow is quite different. Some foreigners assert, that they cross the seas; but from our own observation, joined to the account of the Swedes, it is manifest that several, at least those which reside in the northern countries, continue in Europe; and clinging fast with their bills and claws

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to one another, bury themselves in some dark subterraneous cavern. Whole multitudes of them resort to places unfrequented by any human creature, and some conceal themselves in the very waters. The care which they take, before they retreat, to oil their feathers well, and to roll themselves up in a heap, their heads within, and their backs without, secures them from any harm, whilst in the winter, and in hard frosts, even under the ice itself. Their little hearts, however, have an uninterrupted palpitation; and, at the return of spring, the sun's genial heat dissolves their frozen limbs. Thus set again at liberty, they revisit their former habitations, and each individual bird finds out its proper country, city, village, and nest.

As to wild-ducks and cranes, both the one and the other, at the approach of winter, march off in quest of milder climates: both of them, like quails and swallows, assemble on a certain day: they decamp in a body, and it is an agreeable amusement to observe the order of their flight. They range themselves, for the generality, in one long column, like the letter I, or in two lines, united in one point, like the letter V reversed. The wild-duck, or crane, that forms the point, cuts the air, and facilitates the passage of the rest. However, he is charged with this commission but for a short time, at the expiration of which he falls back into the rear, and another assumes his post. There are several other instances of dexterity and address ascribed to them.

Though we frequently observe, that birds annually assemble on a certain day in autumn, in order to march off in a body—though we have often seen a flight of these birds of passage on their journey—yet we have always thought the fact very surprising. When we reflect on their progress over seas and kingdoms, we are at a loss to determine which of the two is the most miraculous circumstance—the prodigious force that supports them through such a tedious passage, or the order and discipline observed by them in the execution of it. Who informed their young, that it would be highly requisite to abandon their native land,

land, and travel into a foreign country? What particular bird takes the charge upon him, of assembling their grand council, and fixing the day of their departure? Who sounds the trumpet, that informs the whole clan of the resolution taken, in order that each individual bird may be in readiness for the march proposed? Have they any kalender, by which to determine the reason, and the very day of their removal? Have they proper magistrates to preserve that discipline and decorum, which is so strictly observed among them? For, till the proclamation be published, not one of them presumes to stir; and yet, on the day succeeding that of their departure, there is not one straggler or deserter to be seen. Have they any particular charts to direct them in their course? Have they any knowledge of what islands lie in their road, where they may rest and refresh themselves? Have they any compass to be their infallible guide to the coast proposed, without having their measures disconcerted, either by accidental rains, adverse winds, or long, dark, and dismal nights? Or, in a word, are they endued with a degree of reason superior to that of man himself, who would never rashly venture on such a tedious passage, without being first furnished with an infinite number of machines, and a sufficient store of proper provisions?—Doubtless the Almighty is their guide and their protector, and imprints on the mind of each individual bird a particular method, and such ideas as are suitable to its nature.

Having mentioned the particular species of the inhabitants of the air, who sing their matins before the rising of the sun, and perform their vespers, by way of homage, after he is set, we shall conclude this chapter with a word or two on night-birds in general.

Amidst the general approbation of the light, these birds of darkness alone profess their utmost horror and detestation of it: they avoid it as their most implacable enemy, they will never suffer it to be an eye-witness of their actions, and, while it cheers and enlightens all nature besides, they hide themselves in the most gloomy caverns. They wait with impatience for

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for the return of darkness, that they may steal out of their lonesome prisons, in which the hated day-light had confined them, and then they testify their joys by the most hideous screams. Though all of them have a cry peculiar to their respective species, yet all of them in general are disagreeable and shocking to the ear. Their very form has something in it wild, frightful, solemn and gloomy, and we may discern an irreconcilable aversion to man, and every other living creature, in their very features. The generality of them have crooked bills and short talons, out of which their prey, once seized, can never escape. Those hours of darkness, which were designed for slumber, and the refreshment of nature, are employed by them in suppressing other birds that are unguarded and asleep. It is with difficulty that the most vigorous avoid them, but the weakest are their certain prey. They add, likewise, cruelty to surprise, and rage to artifice; and, after they have been vigilant for the public calamity, they retire, before the rising of the sun, to their dark, solitary abodes. They prefer, for the generality, old castles, and uninhabited buildings, to all other recesses whatsoever, as if desolation and melancholy ruins, which denote the neglect of the owners, or subversion of families, were capable of inspiring these ill-omened birds with sentiments of joy.

As these birds of night are implacable enemies to every other species, so they, on the other hand, are equally the objects of abhorrence and detestation, in so much that, as soon as either the little owl, the great owl, the horn owl, the osprey, or any other night-bird whatever, is detected, either through want of sufficient precaution in the concealment of its habitation, or its hideous and abominable hooting, there is an universal combination against the ill-omened creature: both small and great flock round about him, and attack him as their common enemy.

CHAP. III.

Of Fishes.

WE have always observed, that the world abounds with an infinite variety of living creatures: some are inhabitants of the air, while others range around the fields, or crawl upon the ground. Thousands reside in the utmost recesses of the thickest woods, in the hearts of leaves, and under the barks of trees: some in the chinks and crevices of walls, and others in the most gloomy caverns: the very bowels of the earth are hollowed and filled with inhabitants. All these animals, how different soever from each other, with respect to their nature and way of life, enjoy one benefit in common: all of them breathe the fluid air. We have, however, at present, another element under our consideration, wherein all those we have just mentioned are killed, as soon as they are plunged into it. Is there no possibility then of subsisting in the water? and is that element, which covers more than half the globe, entirely uninhabited?—Just the reverse; we therein discover a vast variety of beings, and observe that as terrestrial animals are suffocated in the waves, so the inhabitants of the watery regions soon expire in the air, and cannot long subsist out of that element to which they are consigned.

Such animals as live upon the earth, are either furnished with feathers, and a delicate down, or invested with close and warm furs, or long hairs, to defend them from the inclemency of the air, which is sometimes exceedingly cold. Though fish has not any thing of this kind, yet nature has provided for them in such a manner, as to enable them to subsist in an element much colder than the air. Let our fair readers recollect what they must have often discovered, as they have been accidentally handling a fish, or cutting one open: the first thing that offered itself to their touch, was a certain glutinous matter, with which the whole surface of the creature's body is duly moistened. They must

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must have found, moreover, a coat, consisting of strong scales; and before they came to the animal's flesh, must likewise have observed a kind of lard, or oily substance, which extended from head to tail, and surrounded the whole.

Though we cannot easily conceive how these scales are formed, or how they gradually increase and are supplied, or what is the origin and reservoir of this oil, yet these scales by their solidity, and their oil by its antipathy to the water, keep the fish warm, and give him life and vigour. He could not possibly be furnished with a lighter vestment, or one more impenetrable; inasmuch that, which way soever we turn our eyes, we discern a wisdom ever fruitful in new designs, perfectly well acquainted with every circumstance of its operations, and never opposed or incommoded by the disobedience of the materials it employs.

When we are tempted to the summit of some high hill by the sea-shore, from whence our eyes may take a boundless range over that immense basin, which was hollowed by the hand of the Almighty, we find ourselves at a loss for words to express our wonder and admiration. Great as the extent is, it is filled with animals, whose flesh afford us the most wholesome and delicate food, which we are always sure there to find, if we will be but at the trouble of seeking it. We have an additional blessing in the reflection, that such fish as are wholesome food, and agreeable to the taste, are exceedingly prolific; while those, on the other hand, whose flesh is unpalatable, or prejudicial to our health, and whose monstrous size renders them formidable to others, are, for the generality, vivaporous; that is to say, they bring forth their young completely formed into the world, and seldom more than one or two at a birth: of this number are the whale, the dolphin, the porpoise, and the sea-calf. The same wisdom that has regulated, with such indulgence, the bounds of their fecundity, keeps those at a wide distance from our shores, which we have the least occasion for, and puts others in our possession, which are of most benefit and advantage to us.

Whales,

Whales, porpoises, and all the fish of an enormous size, whose awful appearance would alarm those which nourish and support us, and fright them away, seek the high seas, to prevent their being driven on the coast, where they would be lost for want of a sufficient body of water to support them. An invisible hand directs them to such parts as are abandoned by the rest, and prepares for them a subsistence, hitherto unknown, under the congealed waters of the North, and all along the seas that lave the coast of Greenland. On the contrary, all the other species come in shoals to our coast, some are with us all the year long, and others pay us an annual visit in prodigious multitudes. The exact time of their passage, and their peculiar track, is perfectly well known, which are very advantageous circumstances.

We may form an adequate idea of other fish of passage from herrings alone. They seem to have their principal rendezvous between the points of Scotland, Norway, and Denmark. They are not, however, a gang of banditti, that rove about at random, but perform their voyage annually with the utmost exactness. June and August are the two stated periods for their being in motion. Their track is prescribed, and their voyage regulated: the whole body move at once: not one of them presumes to straggle, pillage, or desert, but continue their voyage from one coast to another, till the appointed period. They are a numerous nation, and their passage long; when the body of their army, however, is once passed, not one of the same species appear again till the year ensuing.

Some Dutch, as well as our own fishermen, (desirous of discovering the true motive that inspires the herrings with that taste for travelling) have taken particular notice, that an infinite number of worms and little fish are bred every summer in the Channel, with which the herrings regale themselves; and when they have absolutely cleared the seas in the northern parts of Europe, they descend towards the South, to which they are attracted by the pleasing prospect of a new stock of provision. Should they chance, however, to meet with a disappointment, they steer another coast for their subsistence:

subsistence: the passage, indeed, is performed in less time, but the fishery is not near so advantageous.

But let us hasten to another point. The form or figure of all fish in general being straight, and growing always somewhat taper at the head, enables them to traverse the water. The tail, by the assistance of the muscles, is exceedingly pliant, strong, and active; inclines to the right and left, and when reduced to a direct line, repels the water that lies behind it; immediately it resumes its playing, and, by this alternate motion, advances the head, and, in short, the whole body, in a much more agreeable manner than an oar at the stern of a boat, worked alternately to and fro, conveys it up a river. The fins, which lie under the fish's belly, are sometimes of singular service, not only in repelling the water, and advancing the body, but in stopping its course, when they are extended, and lie at rest: their peculiar office, however, is to direct the movement of the body, by keeping it in an equal poise, so that in case the fish should only move its fins on the right side, and bring those on the left close to its body, all the motion is in an instant determined to that side; just as a boat that has two oars, when but one is made use of, it will infallibly turn to that side whereto it is impelled by the working of the other. If you cut off the fins of a fish, the back, which is heavier than the belly, being no longer in an equilibrium, will either lie asslant, or be directly turned up; as is the case with dead fish.

We have already, in pages 70 and 71 of this work, sufficiently described the method in which the generality of the inhabitants of the water ascend and descend in that element: we shall here, however, mention an experiment many years since published in the Philosophical Transactions, which will infallibly prove what we before advanced, that no fish, after its bladder had been pricked, could rise in the water. The experiment was made upon a live carp.—As soon as the air was pumped out of the vessel of an air-pump, in which the fish was enclosed, it was expected every moment that the air, which remained in the fish's bag, would be expanded; because that element is always endeavouring

endeavouring to accomplish its enlargement, and because at that time there was no air from without to gravitate on the carp. The affair answered every expectation: the air, dilating itself in the bladder, bloated the fish to that degree, that his eyes started out of his head, and at last the bladder burst within his body: the carp, notwithstanding, did not die, but, as he was instantly thrown into the water, lived above a month after the operation. He never rose again, but crawled at the bottom like a serpent.

CHAP. IV.

Of Insects.

THOUGH the minuteness of insects may, at first view, seem a just argument for that contemptible idea which the vulgar entertain of them; though the unthinking part of mankind may look on them as the result of chance, or the refuse of nature; yet he that views them with due attention, and reflects on the art and mechanism of their structure, which collects such a number of vessels, fluids, and movements into one point, and that, too, frequently invisible, cannot but discover an all-wise Providence, that is so far from treating them with neglect, that he has not only clothed them with a profusion of pomp and magnificence, but furnished them with all such warlike instruments as are requisite to their condition.

Every insect that flies or creeps is a little animal, consisting of several ringlets, which shrink from or draw near to one another by one common membrane or skin that collects them; or else of distinct scales, which play to and fro, by gliding over one another; or, in short, of two or three principal parts, which have no other connection than a ligature or little thread.

Of the first kind are all worms in general, as well such as have feet, as those that have none. When they

they are disposed for motion, they extend the muscular skin which divides the two first ringlets. They advance that nearest the head, and sometimes that nearest the tail, to a certain point. Then the second ringlet is drawn after it, either by contraction or expansion of the membrane, which belongs to that particular part. The third and fourth, and so the whole body successively, moves along by the same effort. Even those little animals that have no feet, pass in the same manner from one place to another, rise out of the ground, or withdraw into it, upon the least apprehension of danger, and, in short, proceed or retreat as occasion requires.

Of the second kind are flies, May-birds, &c. whose bodies are an assemblage of divers little scales, which by unfolding expand themselves, or, by sliding over one another, contract, like bracelets in a suit of armour.

Of the third kind are ants, spiders, &c. whose bodies are divided into two or three parts, and whose connection is imperceptible, at least to the naked eye.

Let us now proceed to give the origin or first state of insects; after which we will pass on to their second and last state. Each proceeds from an egg, in which the seed and first nutriment is enclosed. This egg is the product of a male and female. The latter makes choice of such place to lay her eggs in, as appears to her most commodious, and where she imagines there is heat sufficient to hatch them, and where her young, when they are released from their confinement, will find all convenient subsistence in the places round about them. In short, insects, like all other animals, are first produced by way of generation, and then come to maturity by gradual culture, which preserves the species.

Let us, in the next place, consider what this egg contains. The fruitfulness of the egg is dependant on the male; and then there is a little worm, amidst the delicate nutriment inclosed in the shell, which, though imperceptible to the naked eye, has been discovered in a microscope by the curious Mr. Lewenhoeck, who

who was one of the most celebrated natural philosophers of the last age. This diminutive worm, thus enclosed and protected by the shell, is nourished in the most tender manner by the liquid in which it swims. Its bulk is gradually augmented, and then being pent up too close, it bursts its shell, and finds itself, by the care and circumspection of its parent, provided with a stronger aliment, and better adapted to its new state.

Some, at the first opening of the egg, are perfect in their shape, and never lose it whilst they live. Of this sort are snails, who leave the egg with their house on their back. They will preserve the same form, and the same house; there will be some additional circles, indeed, to their shells, as they encrease in bulk. Spiders are in like manner complete at first, and change nothing but their skin as they grow large. Most insects, however, pass through a variety of transmigrations, and assume the form of two or three living creatures successively, which bear no affinity or resemblance one to another.

Our fair readers will perhaps think we are sporting with their credulity, when we assure them, there is a certain country, where a vast variety of animals are to be seen in different forms; some living low on the ground, others sporting in the water, which, in process of time, assume new shapes, live on the surface of the earth, and crawl like serpents, through groves and meadows for a while; then eat no more, but erect themselves a dormitory, or sepulchre, where they lie for some months, and sometimes whole years together, to all outward appearance, without life or motion; and yet at last revive, are transformed into birds, break through their prison-walls, display their radiant feathers to the sun, expand their wings, and commence gay tenants of the airy regions.—Patience, fair readers, that country is our own, and these gay birds are flies, caterpillars, wasps and bees, which daily present themselves before our eyes.

These insects, and many others, at their first issuing from the egg, are little worms, and nothing more; some with, and others without feet. The latter are

left to the care and conduct of their parents, who provide, not only commodious cells or lodgments for them, but proper food for their support. The former look out for provision for themselves upon some tree or other, most agreeable to their natures, and the very same whereon their parents wisely placed them. In a short time they encrease in bulk. Several of them cast off their old skins, and assume new ones; then change them again and again at certain periods. All of them afterwards (we mean all those that undergo any change) pass through an intermediate or middle state, called by the naturalists, either the *nymph*, the *chrysalis*, the *cone* or *beau*. These are several titles or denominations made use of to express much the same thing, and require a short explication. The minute worm, as we before observed, ceases to eat, encloses itself in a sort of tomb or little monument, which varies in its form according to the species; but all of them in general are erected after a very uniform and regular manner. There, under a cover, which preserves its surprising delicacy from all insult, it is again conceived and born anew. At that juncture the naturalists give it the title of a *nymph*, that is, a young bride; because the insect then puts on its gaudiest dress, and appears in its last form, wherein nature intends it shall multiply its species by generation. This is called the *chrysalis*, the *aurelia*, or the *golden nymph*; because the little skin, whether hard or tender, is gradually died with the brightest and most lively colours. It is called likewise the *cone* or *beau*; because it is covered, for the generality, at that time, with a hard skin, like the shell of an egg, or the coat of a beau.

In fine, their fourth state, their grand and principal metamorphosis, is, when they arise, out of their dormitories, and become flying insects; they then burst the covering that encloses them, display the plumage of their heads, and expand their wings.

The various species of caterpillars, already well known to the curious, amount at least to three hundred. Naturalists, however, are making new discoveries. Though one species differs from another in form, colour, inclination, and diet, yet every thing

is uniform in one and the same species. All of them are composed, like silk-worms, of various ringlets, and by the dilatation, and contraction of their parts, between them, transfer themselves from one place to another as occasion requires. They have a certain number of feet both before and behind, which have several little joints that bend and play at pleasure; and nature has furnished them with claws, that they may fasten themselves more firmly to the bark of trees, especially whilst they are asleep. The generality of them have a thread, the substance whereof is a liquid gum, that they extract from the leaves on which they subsist. If they find themselves in danger of falling a prey to some bird, or of being crushed to pieces by the agitation of the branches, they first shed a small part of that glutinous matter upon the tree, then, throwing themselves headlong, spin it, as they descend, through several little orifices of their body; from whence are formed as many different threads, which they collect with their claws, and twist together so artfully, that, having first moistened them with a natural glew, they form one single thread of sufficient strength to support their weight. This serves her as a strong chain to support her when she launches herself out of impending danger, and afterwards as a ladder to recover her former station.

The generality of caterpillars are tinged with one principal colour, in all respects resembling either that of the leaves whereon they subsist, or the branches on which they fasten themselves when they cast their skins. The caterpillar that subsists on the buckthorn is, like the plant, all over green; that which feeds on the elder, assumes the colour of the tree. There are numbers of these animals to be found on dwarf-trees and apple-trees, that are as brown as the wood of those plants. These last very carefully quit the leaves, and trail along the branches with the utmost precaution. By these means they are confounded with what they subsist on, are not easily discerned, and escape the birds that are in pursuit after them, during their state of inaction.

Towards the close of the summer, and sometimes before, these caterpillars, after they have glutted themselves, and cast their skins several times, eat no more; but are intent on erecting a kind of monument, in which they are to resign both their lives and forms, in order to be metamorphosed into butter-flies. One would imagine they were conscious of the precise time of their continuance in the state of nymphs, since their little sepulchres, with respect to the solidity of the building, are proportioned to such duration. Those, who are to lie in that state of non-existence but a few days, make choice of some tender leaf, which they render still more pliant by diffusing a kind of glew upon it. The leaf gradually curls up, and, withering as it enfolds the insect, assumes its form, and serves as a mantle and a fence from the injuries of the weather, till the sun's enlivening heat, and its wings, enable it to break through its confinement, and fly away. Others, whose time of transformation is likewise near at hand, fasten their tails to a tree, or to the first worm-hole they meet with under a beam, or in a shelf; or else hang by a thread, or drop of glew distilled on some vine-drop, with their heads downward. They throw themselves into a sweat; which condenses, and when dry looks like scales all round about them. Sometimes they appear under the form of an embryo, wherein all the parts of the insect, in due time to arise from it, lie confused in a consistence, which contributes, no doubt, towards the formation of it. In a word, this embryo, or chrysalis, by some small agitation, disengages the paws and wings, which were before invisible, and confined under its cover; and then the papilio, thus set at liberty, takes her flight, and ranges at pleasure round the meadows.

Such caterpillars, on the other hand, as are conscious that they shall lie several months, and, perhaps, the whole winter, in the state of nymphs, act in a quite different manner, and with much greater circumspection. Most of them agitate their bodies, till they are perfectly covered over with sweat; then rowl themselves on a bed of sand, the grains whereof, being gathered into a body, become a kind of incrusta-

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tion. Thus they build themselves, as it were, a monument in stone, under which they wait with patience for their final transformation.

Others build in wood, which serves them in the nature of a coffin. Such as have made leaves of willows their favourite food, break the tender twigs of them first into small pieces, then pound them, as it were, to powder; and, by virtue of their sweat, and their glutinous matter, mingled together, make a kind of paste of the whole, in which they wrap themselves up: so that the paste, when crusted over them, assumes the form of a mummy, and is the mould, as it were, of the papilio that is to arise from it.

Such caterpillars as are most common, and with which we are best acquainted, are to be seen, in vast numbers, on our elms, apple-trees, and bushes. The papilio, that owes its existence to them, makes choice of some beautiful leaf, whereon she fastens her eggs in autumn, and dies soon after, stretched out, and glued on her beloved progeny. The sun, whose rays have still some influence, warms her eggs. Before winter, vast numbers of little caterpillars burst out of their prisons; and, though they never saw their parent; yet, without any plan, or previous instruction, are ambitious of excelling each other in the art of spinning, and by their industry weave themselves beds, and commodious mansions, where they shelter themselves from the cold winter blasts, in distinct apartments, without the least sustenance, and oftentimes without so much as stirring once abroad. There is only one little aperture towards the bottom of this their habitation, through which the family sometimes fall out to take the air about noon, when the sun shines warm, and the weather is settled. When you are inclined to open these their little mansions, you must make use of some strength to break their tissue, which is as firm as parchment, and not to be injured by wind, cold, or the most rapid showers. There the whole brood lie extended at their ease on a thick down, entwined in divers folds of their own weaving, which supplies them with their coverlids, their curtains, and their tents. In this manner they pass the whole

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winter, without any subsistence. But, indeed, since they lie dissolved in sleep for several months together, and as there is no dissipation of their animal spirits, they stand in need of no manner of refreshment. However, all these drowsy caterpillars awake in spring: the first shooting of the leaves create them an appetite: they sally out in the day-time, and withdraw to their respective apartments when night comes on, or the weather is bad.

Whoever opens one of the embryo's, whose transformation is near at hand, will find at first nothing but a congealed mass, or a kind of corrupted matter, wherein every thing is confounded. In that petrification, however, the seeds, or elements, of a most agreeable existence are implanted, which gradually transpire across the little skin that contains them: that skin grows redder and redder by insensible degrees, the liniments, which lay confused, begin to appear distinct, and the creature at last forces its passage through the prison wherein it lay confined. The head disentangles itself, the antennæ are lengthened, the legs and wings extended; in a word, the butterfly takes her flight into the air, and retains no resemblance of her former state. The caterpillar that was transformed into a nymph, and the papilio that arises from it, are two distinct animals: the first was a dull heavy creature, and only trailed along the ground; the second is all life, activity itself, has no concern with the earth, and disdains, in some measure, to rest upon it: the first was something disagreeable to the aspect; the other is dressed in all the gawdy colours of the rainbow: the first, incurious, confined itself to gross provisions; the last takes a boundless range from flower to flower, lives on honey and roses, and for ever indulges itself in a variety of pleasures; in short, enjoys nature without restraint, and is one of her most favourite productions.

Having thus copiously treated of caterpillars, let us now proceed to spiders. There are five sorts of spiders: first, the *house-spider*, that spins her web in garrets, and such other apartments as are most neglected. Secondly, the *garden spider*, that weaves, in the

the open air, a little circular web, the center whereof is her constant situation in the day time. Thirdly, the *black-spider*, that builds in cellars, and the ruins of old walls. Fourthly, the *vagrant-spider*, who has no settled habitation as others have. And, fifthly, the *field-spider*, called the *long-legs*. All these spiders have something in common with each other, and something likewise peculiar to themselves.

Every spider has two divisions: the fore-part, containing the head and breast, is separated from the hinder part, or belly, either by a ligature or very slender thread. Her fore-part and fore-feet are covered with strong scales, and her hinder-part with a supple skin: the whole is clothed with hair. They have five eyes in divers parts of their heads, eight for the generality; sometimes, however, they have but six, two before, and two behind, and the rest on each side of their heads. They have no eyelids, and are fortified with a hard, polished, and transparent crust. As these eyes are immoveable, nature has indulged them with so large a number, to give them information of every thing that any ways concerns them. All of them are furnished in the fore-part of their heads with two stings, or rather two rough branches doubly pointed, or indented like two saws, terminating with a nail, like a cat's claw. A little below the point of the nail, there is a small orifice, through which we find, by experience, that they diffuse a very strong and baneful poison. They have no other weapons so formidable as these, or so fatal to their enemies: they either open or extend these two branches as occasion requires. When they make no use of their two nails, they let them fall down on their respective branches, like a vine-knife clasped upon its haft. All of them in general have eight legs, with divers joints, like crabs-claws, and at the outmost point of these legs, three crooked moveable nails; that is to say, a small one fixed on one side, in the nature of a spur, by the assistance of which they hold fast by their thread, and two others considerably larger, which they make use of either to fix themselves to one spot, as they see convenient, or to walk obliquely, or with their backs

downwards, by catching at every thing that falls in their way. When they walk upon such bodies as are perfectly smooth, for instance, on a piece of polished marble, or a looking-glass, they squeeze a little sponge, which they carry between their claws at the extremity of their feet, and from thence diffuse a glutinous matter, which enables them to stand fast, without depriving them of the power of proceeding further. Flies have, in like manner, sponges at the extremity of their feet, and it is the pressure of them that occasions those little round specks, which we frequently discern on our glasses, or china-ware, and such other bodies as are most polished. Beside the eight legs above-mentioned, the spiders have two others before, which may, with propriety enough, be called their arms, because they seldom make use of them on any other occasion, but to secure and hold fast their prey. The spider, though thus formidably equipped, would seldom prove successful in her wars, were she not equally furnished with other instruments to form an ambuscade. She has no wings to help her in the pursuit of her prey, as her prey has to make its escape. The disproportion therefore would be too great, if the spider had not a large quantity of thread in store, and was not constantly employed in spinning new webs, and forming new hostile devices. She spreads her snares therefore in the open air, where her prey is passing and repassing every moment. Nature directs her when she should begin to work, and that is whilst her prey is very young; and then withdrawing into some obscure corner behind her net, she waits with patience for the enemy, who has no apprehension of her treacherous design.

Let us enquire into the method she observes in the working and contriving these artificial snares, which prove so advantageous to her. All spiders have five dugs or teats, at the extremity of their belly, covered over with others of a lesser size, the orifice whereof they not only open and shut, but dilate and contract, as occasion requires. Through these openings they distil and weave that glutinous matter, of which they have an almost-inexhaustible stock in their bellies.

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According as the insect discharges this clammy gum, through one or more of these orifices, the threads are extended in proportion to the creature's distance from the place where she first fixed it. When she contracts the orifices of these her little teats, the thread is lengthened out no further, and she is suspended in the air. After this, she makes use of her thread, to ascend to her former station, by grasping it in her paws, as a sailor swarms a rope with his hands and knees. With this thread she spins herself a web. She removes, from time to time, the dust that gathers about her web, which would otherwise incommode it: for which purpose she gives the whole a shake with her paw: she weighs, however, what she does so well, and so artfully proportions the blow, that she never disconcerts a single thread.

She has several threads, drawn from every part of her web, which terminate like rays in the center, wherein she withdraws, and waits with patience for her booty. Whenever one of these threads is touched, though in the gentlest manner, she perceives the motion, is apprized of her game, and springs on it in a moment. Another advantage which she reaps from this contrivance of a cell or retreat behind her web, is this, that she can feast upon her game with all the safety imaginable, and conceal the fragments of those carcases which she has picked, without exposing to public view the least footsteps of her barbarity, which might distinguish her place of abode, or create the least jealousy in any insects, that their enemy was near them.

We shall pass over in silence the other species of spiders, contenting ourselves with what we have already mentioned of the house-spider. We might, indeed, with propriety enlarge on the wonderful care which these little animals take in the preservation of their eggs, which they never suffer themselves to be robbed of, but at the expence of their lives: brevity, however, obliges us to proceed to another subject.

There is scarce any species of the common fly, how weak and despicable soever it may appear at first

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view, but what is possessed of five or six natural endowments, which are of singular service upon all occasions: for instance, it has two fine eyes, two horns, and a trunk in its head, a pair of wings on its back, several little claws and sponges upon its feet, and a piercer in its tail.

The eyes of this little animal, like those of beetles and dragon-flies, are of a particular structure: they consist of two little half-moons, or immoveable pads, planted all round the head of the insect, and composed of an infinite number of little eyes, or minute chrystalline humours, ranged in cross lines, like lattice-work. Under these, the very same number of fibres, or optic nerves, are to be discerned, as there are facets or planes without; and Lewenhoeck affirms, that he has counted several thousands on each side. But, be that as it will, it is certain, that all those facets, or small partitions, are so many little eyes, whereon external objects are painted, as on so many mirrors.

Her trunk consists of two parts, one whereof folds over the other, and both are sheathed within her mouth.

At the other extremity of her body she has an auger, of above three-twelfths of an inch in length, with which she pierces through what she sees convenient, and then sheaths it under her scales. This impliment is composed, in the first place, of divers parts; as, for instance, of one or two saws, sharply pointed and indented all along. Secondly, of a long case to enclose them. Thirdly, of several strong muscles to dart them out, and divers fibres to retract them as occasion requires. And, lastly, a bag of corrosive water, in order to eat into such hollow places as have been first opened by the saws. The fly makes use of this auger, to prepare a convenient lodgment for her eggs, and makes choice of such leaves as are most luscious and juicy, and such as are not too soft; because the saline particles are rather apt to lacerate the tender organs of their young ones, than to nourish and support them. From their eggs proceed several little worms, which are afterwards transformed to nymphs, and then to flies.

Gnats

Gnats deposit their eggs on a lay of glew, on the brink of the water, from whence proceed divers animalcula, which pass through three different states: in the first place they live in the water; then they change, from being aquatic creatures, to such as are amphibious, living sometimes in the air, and at others in the water; and, lastly, they are inhabitants of the air only.

The gullo-talpa, or mole-cricket, is about three inches in length, has two horns before, and two behind, to give it information of all that passes in that dark cell wherein it resides. It has, moreover, a long tail, a pair of little, strong, short wings, and two arms, with two formidable saws. Like a mole, it lives under ground, and mimicks the chirping of a cricket.

The ants are a little people, united, like the bees, in a republic, which has, if we may be allowed the expression, its peculiar laws and policies. They have a kind of oblong city, divided into several streets, which terminate at divers magazines. Some of them are employed in compacting the ground, and preventing its falling in, by incrusting it all over with a kind of glew. Such as we generally see, get several little splinters or small parcels of wood together, which they first draw over the tops of their streets, and make use of as beams to support the roof. Then they lay another row of splinters across the former, and cover them with a sufficient quantity of rushes, grass, and dry straw. These are raised with a double declivity, to divert the course of the water from their magazines; some whereof are set apart for the reception of their provisions, and others for the lodgment of their eggs, and such vermicelli as proceed from them.

As to their provisions, whatever is fit for eating is agreeable. You shall see one dragging along, with the utmost difficulty, the kernal of some fruit, and another almost sinking under the cumbrous load of a dead knat. A whole swarm of them shall sometimes be employed at once about the carcase of a may-bug, or some such other insect. They eat, without reserve or delay, whatever they are incapable of removing;

but what can possibly be preserved, is carried home with all the care and circumspection imaginable. Some ants have been seen carrying, or rather pushing before them, several grains of barley or wheat considerably larger than themselves. There are few, however, who have been so fortunate as to discover their grain-ary : all the ancients make mention of it, and Aldrovandus assures us that he had seen it. It is probable that their labours, as well as their inclinations, may differ according to their species.

The ants, after they have spent the whole summer in one continued scene of hurry and fatigue, confine themselves within their cells all the winter, and reap the fruits of their labour in peace and tranquillity. It is highly probable, however, that during their retreat they eat but little, and are either benumbed with cold, or, like several other insects, dissolved in sleep. From whence it is reasonable to suppose, that their industry in hoarding up their provisions is not so much intended to guard themselves against future exigencies, as to secure, during the harvest, a necessary subsistence for their young. They rear them, as soon as they are hatched, with that tender regard that employs the whole community ; and the maintenance and welfare of their little ones is looked upon as a concern of the last importance to their republic.

In Africa, and particularly in Guiney, the ants are exceeding troublesome, and do a great deal of mischief. They make their nests, twice as high as a man, of earth in the fields ; besides which they build large nests in high trees : from which places they advance to the European settlements, in such prodigious swarms, that they frequently oblige the inhabitants to quit their beds in the night time. They will sometimes attack a living sheep, which, in a night's time, they will reduce to a perfect skeleton, leaving not the least thing except the bones. It is common for them to serve domestic fowls in the same manner, and even the rats themselves cannot escape them. If a worm or beetle is placed, where only one or two ants are, they will immediately depart, and bring with them above
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an hundred of their own tribe; after which they seize their prey, and march off with it in good order.

These ants are of various sorts, some great, others small, some black, and others red; the sting of this last is very painful, and causes an inflammation; the white are as transparent as chrystal, and have such long teeth, that in a night's time they will eat their way through a thick wooden chest, and make it as full of holes, as if it had been penetrated by shot.

There are several sorts of ants in the East-Indies, whose numbers are prodigious; some of them are exceeding large, and of a ruddy colour, inclining to black, and some have wings, but others have none. They are very pernicious to the fruits of the earth, and do a great deal of mischief in houses, unless great care is taken to prevent them. It is remarkable, that if one ant meets another that is loaden, it always give way to let it pass freely.

Let us proceed to say something of the beetle, which is a flying insect, with a case over its wings, to defend them from danger when they fly: though some will have these cases to be a different sort of wings, and therefore place them among four-winged insects, but very improperly; for they seem to be designed by nature, to preserve their wings from hard bodies, which they often meet with when they dig holes in the ground, or gnaw rotten wood with their teeth, to make themselves houses or nests.

When they fly, they fill the air with a humming noise, and perhaps greater than that of any other insect. They have a great aversion to roses, whose smell they cannot bear, and some affirm it will kill them. They are naturally fond of ivy, and delight to get under its leaves. There are so many different sorts of beetles, that it would tire the patience of our fair readers, even were we but to give a bare catalogue of their names.

Of this species of insect is the may-bug, who has two pair of wings, one of which may properly be called the cases, and the other the real wings. These cases are hard, and of a reddish brown, sprinkled with a whitish

na whitish dust, which easily comes off. The legs and tail are whitish, but the rest of the body is brown, except a white and dentated line, wherewith each joint is marked on both sides the belly.

It is thought that the females make holes in the earth with their tails, with a view to encrease their species, but it is uncertain whether they lay eggs or small worms. Be that as it will, these worms are prejudicial to the roots of corn and young plants; and they are sometimes so numerous, as to do prodigious mischief: they continue so long in this state, that they are the more dangerous upon that account, and it is said the hardest frost will not hurt them.

Rooks and hogs are very fond of these worms, and devour vast numbers of them: hence the advantage of rookeries is very evident, as the inhabitants of the county of Norfolk have found, after having paid dear for the experiment; for they lately took it into their heads to destroy all the rookeries, since which they have been pestered with these worms, which have destroyed the roots of their wheat, to their very great loss: one farm, in particular, was so injured by them in the years 1750 and 1751, that the occupier was not able to pay his rent, which the landlord was not only content to lose, but likewise gave him money for the support of his family.

These may-bugs are seen most frequently flying about in the evening; for in the day-time they hide themselves in the leaves of several trees till sun-set, when they appear in great numbers, and often fly in the faces of passengers.

Moufet informs us, that in 1574 there fell such a great number of these insects into the Severn, that they stopped the wheels of the water-mills. This was on the 27th of February; but the largest sort do not appear till May. In Ireland they suffered so much by these insects, that they resolved to set fire to a wood of some miles extent, to prevent a communication with others at some distance; and, indeed, it is certain, that where there are few trees, and many rocks, the inhabitants are least infested with them.

As we have already exceeded the bounds prescribed to this undertaking, we hope our fair readers will ex-

excuse the omission of many things worthy their attention, and permit us to conclude with the history of that useful and industrious animal the bee.

That there are three sorts of bees in a hive, is a truth beyond all contradiction: the first are the popular, and most laborious part of the nation, who seem to be neither male nor female. Each of them has a trunk to assist him in the execution of his work, and a sting to defend himself in case of an assault, or any invasion. In the second place, the drones, who, for the generality, though not always, are of a darker hue, and one-third longer and larger than the former: these are looked upon to be the males, and those that have no stings. There are about a hundred of this species in a small hive of seven or eight thousand bees; but there are four times the number, when the hive is large, and contains more than seventeen thousand. And, lastly, the third species are not only much stronger and larger than the drones themselves, but they have stings likewise, as well as the populace or common bees. It is the received opinion, that there is but one supreme, or sovereign bee, in each hive, or at least but one in each swarm, that is to say, in each colony of those young bees, who sally out of the hive from time to time, in search of some new situation. This sovereign of theirs is dignified and distinguished by the title of their queen.

The drones have all of them a bag of honey in their bellies, as other bees have; with this difference, that the common sort have their bag continued by a little passage to their very necks, through which they pour out their honey into the general magazine; and, if you squeeze a bee never so gently, the honey will distil immediately through that narrow canal, but you will find no evacuation upon the squeezing of a drone. He eats, and no one but himself reaps advantage of it: he contributes nothing to the public stock; he is well provided for, he does no manner of work, nor even ranges round the fields; he takes a turn or too, indeed, now and then to air himself, and walks round the hive, without the least interruption. As he has no enemy to fear, so nature has given him no sting for his

his defence. It is certain, that such indolent members would not be suffered in a state, so remarkable for their conduct and oeconomy, if they were not reserved for some service or another. Some conjecture, that their principal employment is to furnish the queen with a numerous progeny, or, more properly speaking, to people the state with subjects. The queen herself, in the space of one year, shall sometimes give birth to six or seven thousand young ones; and, by the joint endeavours of two or three other prolific males like herself, shall see her childrens children, and, in one summer, be the first parent of above eighteen thousand descendants.

What seems to be an incontestible proof, that these drones are appointed only as males to people the state, is this, that they are plentifully provided for all the summer season; but, when these queens have discharged their swarms, and autumn approaches, (at which time it is foreseen, that there will not be time or heat sufficient to rear a new family) then the drones are under disgrace, and turned out of doors, as being a burden to the commonwealth: the bees will no longer give them house-room; their malice extends even to such young drones as are still in the egg-shell. They pluck them out of their cells, kill them, and then cast them out of the hive. Their fathers after this feel the weight of their resentment: it is in vain for them to be obstinate, and think of maintaining their station; they lay hold of their wings and shoulders, thrust them out, and harraß and fatigue them: they drive them all out, in short, without the least favour or affection; except, perhaps, a small number of a less rapacious species be maintained at a moderate expence. These few are preserved to supply the necessities of the ensuing year.

The whole community of bees, young and old, live in peace and unity together, as long as there are conveniencies for their reception; but when their number is so far augmented, as to disable them from rearing a new progeny, without abundance of trouble and fatigue, then the old bees, whose right and title are indisputable, make war upon the young ones, if they

they refuse to quit the hive. For the generality, however, the young brood testify all the duty and submission imaginable; and, at a certain day and hour, or rather at one and the same moment, the whole swarm of young bees, with their queen at their head, march out of the hive in form, and take their flight to some distant fields, in search after some other agreeable situation. This young band may, with propriety enough, be called an actual colony. The old bees always maintain their privileges, and never quit their ancient habitations.

Whenever the young brood have taken their flight, they sometimes rove about for a great while, buzzing in the air, in quest of a commodious retreat, and fix in one body or cluster, either on the trunk or branches of some commodious tree. It is a common custom to ring a little bell, or tinkle some brass pans, the noise whereof has an extraordinary influence over them, and at once composes them. It is not improbable, that they are deceived by this sound, and imagine it to be a peal of thunder, and the forerunner of a storm. Be that as it will, at that very juncture, either through some awful apprehension, or particular composure of mind, which that kind of instrumental music may create, they weigh with attention the service that is tendered them. If you oblige them, by a gentle compulsion, to enter into the hive, they take it as an act of complaisance; or, perhaps, their own natural inclinations may induce them to fly there for shelter and protection. After this, though the person, who presents them with the panner, removes it to some other place, yet they comply therewith, without shewing the least mark of their resentment. The hive accordingly is planted upon a stand, composed of several planks laid flat, and nailed close together, in order to prevent any insects, or noxious exhalations of the earth, from having any influence over it. There is care taken, that a small aperture shall be left at the bottom of the hive, and then they range themselves according to the constant method observed amongst them.

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The materials they make use of in their buildings are composed of nothing but glew and wax, which they extract from various flowers. With respect to their fabrick, it is intended as a commodious habitation for themselves and their numerous issue; and, as to the method of their erecting it, we shall enumerate some few instances of their prudence and good conduct.

When they begin to build their nest, they divide themselves into four several bands, or select companies. The first range all over the fields in quest of proper materials; the second work upon the materials that are brought home, and make a rough draught or plan of the intended structure; the third polish and complete it, examine with the utmost exactness the several angles, carry away the redundant wax, and bring the work, in short, to its utmost beauty and perfection; the fourth attend with provisions on such who have not time to leave their work; no allowance, however, is made to that band who are employed abroad, because it is taken for granted that they will not forget themselves; neither is there any portion allotted for those who begin the cells. Their branch of the work is really very difficult and troublesome; because it is their peculiar province, not only to lay the wax smooth, and extend it to its proper dimensions, but to cut and adjust it with their jaws: however, as their labour is very hard, they have orders, or permission at least, to leave off betimes. They then are at their free liberty to range round the fields, to regale themselves with whatever they can find, and make themselves sufficient compensation for their extraordinary trouble and fatigue. Such as attend them, draw their mouths, their paws, and the extremities of their bodies again and again over the whole work, and never leave off till it is polished and completed to their satisfaction. As these last stand in need of frequent refreshments, and are not permitted notwithstanding to desert from their labours, there are attendants always ready to supply them with provisions, whenever they demand them. Their wants are all expressed by signs. The labourer that is hungry, bows down his trunk before his providitor, and this is a sufficient mark or token that he has an incli-

Inclination to eat: the caterer opens his bag of honey accordingly, and pours out a few drops, which roll all along the trunk, and swell each part of it through which the liquor passes. Thus refreshed, he returns to his labours, and repeats his former motions.

Though the accuracy and beauty of their work is surprising, yet these labourers are so active and industrious, that a comb, consisting of a double row of cells, backed one against another, which is a foot long, and six inches broad, is accomplished in a day's time, and is large enough for the reception of three thousand bees.

The symmetry of these combs is very curious; for here the bottom of the cells not only terminate in a point, to receive the little egg, and collect the warmth into one center, but the bottom is composed of little triangular pannels, which unite with the utmost regularity in a point, and answer exactly, pannel against pannel, to the like extremities of the opposite apartments. Their combs are likewise composed of two rows of cells, the bottoms whereof touch each other, and are perpendicularly suspended, with a space between them, large enough for the bee to pass backwards and forwards, and yet sufficiently contracted to secure as much warmth in every part as they can possibly require.

Bees have two sorts of wax, one coarse, and the other fine. The first is of a blackish cast, and more like glew, or thick pitch, than any thing else; the other is a kind of fine rosin, of an odoriferous smell. This last they find about the numberless little grains, which we see on the chives that arise from the bottom of flowers. As to their glew, it is, without dispute, the gum of some plant; but where they find it, no one can absolutely determine.

When they have found a hive, or some other commodious retreat, their first care and concern is to stop up, with this glew, all the cracks and crannies, wherever they find them, and to amend such places as want the least reparations, in order to exclude the winds, and all insects that, without this precaution, might incommode them.

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When the inside of the hive is well pitched, and the bees sufficiently sheltered, they proceed to lay the foundation on the top of the hive; there they make a bed of glew, to which they fasten the first chambers of their combs, which they carry on by proceeding downwards, and enlarging them, till they find there is no room left. The honey-combs are divided into three cantons, or districts; one, where they bring up their young; another, where they deposite their wax for their future use, as occasion shall require; and the third, where they treasure up their winter-stores.

The wax, in one sense, is as necessary for them as the honey itself. With this they build their cells, and not only close the apartments of their nymphs with it, but those too wherein their honey is treasured up. When any casualties happen, any reparations are to be made, or the species multiply too fast, they have immediate recourse to their wax; and for that purpose they take care always to have a considerable stock of it in reserve: they search for it upon all kinds of trees and plants, but particularly the rocket, the single poppy, and, in short, on all sorts of flowers in general: they collect it in their hair, with which their whole bodies are plentifully covered over. It is sometimes very agreeable to see them roll in the yellow dust that falls from the chives to the bottom of the flowers, and then return invested with those very grains.

Their best method, however, of collecting this wax, especially when there is no great quantity of it to be found, is to carry away all the little particles of it with their jaws and fore-feet; to press them hard, and form them into little balls, and then slide them one after another, with their middle-feet, into a cavity or bottom in their hind-feet. This cavity, like a spoon, receives the wax; and the hair, with which their feet are covered, serves to keep their burden steady, and secure it till they get home. They are sometimes incommoded in this work by the agitation of the air, the delicate texture of the flowers, which bend under them, and hinder them from packing

ing up this booty. In this case, they alight on some solid body, where they squeeze the wax into a mass, and wind it round their feet, return to the flowers time after time for fresh supplies, and, when they have furnished themselves with a sufficient load, make all the haste they can to their respective apartments. Though two men could not collect so much as two little balls of wax in a whole day, yet a bee will amass that quantity, and carry it home in one journey. Such as gather the wax from flowers have proper assistance; for there are attendants ready at the hive-door, on purpose to ease them of their loads, as soon as they arrive, to brush their feet, and shake the balls out of them. Whereupon the former repair to the fields again, in order to collect new stores, whilst those who helped them to unload, convey their charge into the general magazine. Some bees, however, have been observed, upon bringing their burden home, to convey it to one of their apartments, and there unload it themselves, laying hold of it with their hind-feet, and with their middle-feet sliding it out of the cavity wherein it was contained. This, indeed, was apparently a work of supererogation, and what none of them is under any obligation to perform. These little balls lie some few moments in the cell, till some new-commissioned officers come in to knead this wax, and spread it out with their feet, into different lays heaped one upon another. This is the unpolished wax, which we may easily perceive to be the produce of divers flowers, by the variety of colours that are visible in every lay. Afterwards, when they come to manufacture it, they knead it over again, purify and blanch it, and make it all of a colour. They are very frugal in the use of this wax. We may easily observe, that the whole clan is inspired with uncommon prudence, and that each member is under the strictest regulation. They are allowed every thing that is necessary, but nothing that is superfluous; not the least grain of wax is thrown aside or neglected. If they happen to make any waste, they are frequently employed in searching out for more, even when they want to lay up their provision of honey.

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honey. For instance, when they open these cells where their honey is deposited, they take the wax with which those holes were stopped up, and carry it into their magazine. One more instance of their good management is, that, when a young bee has disengaged itself from its confinement, by breaking down the waxen partition that enclosed it, two old bees immediately come to the place, carry away all the remains, repair the lodge of the cell in a substantial manner, and convey into their reservoir all the little particles of wax that are scattered round about it. Thus there is nothing lost.

Such of our fair readers as have the opportunity of viewing the labours of these industrious animals through a glass hive, will not only be convinced of the truth of what we have now asserted; but will discover many things here omitted, equally wonderful and surprising.

As to honey, the ancients were of opinion, that it was an efflux of air, a dew that fell upon the flowers; as if by the appointment of Providence, it was to descend upon nothing else. However, the moderns have discovered, that dews and rains are of a quite different nature; that they wash the honey away, and prevent the bees from finding it. Honey is rather a perspiration of the finest particles of the sap in plants, which evaporate through the pores, and afterwards condenses on the flowers; and as these pores are more open when the sun shines warm, than at other times, so the flowers are never more replenished with a viscous and vermilion juice, neither are the bees ever more gay and sprightly, than when the sun shines in its meridian lustre. Violent rains either carry away the best salts from the soil, or dilute its purest juices; as, on the other hand, a long, tedious, dry season, hinders those juices from flowing into the plant.

To conclude, a hive is a school, to which too many of the human species ought to be sent. Prudence, industry, love of our neighbour, zeal for the public good, neatness, temperance, and, in short, all virtues are conspicuous in bees; or, to speak more properly, they read us lectures on those moral subjects. These little

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Little animals are influenced by that social spirit, which forms them into a body politic, strictly united, and perfectly happy: they all toil for the public good: they are all obedient and submissive to the laws and orders of the community: they have no sinister views, no distinctions, but those which nature, or the emergencies of their little state, have introduced among them: we never find them restless and uneasy, or inclinable to abandon their hives in times of necessity: they imagine themselves in a state of perfect freedom, possessed of all the enjoyments of life: and in reality they are so: they are free, because they have no dependance but on their laws: they are happy, because the occurrence of their joint endeavours produce an affluence, which constitute the riches of each individual. — But, when we compare human societies with this, how contemptible they appear! Necessity, reason, and philosophy, have formed them under the laudable pretence of doing mutual good offices; but a spirit of self-interest destroys all; and one half of mankind leave the other indigent and naked, that they may indulge themselves in all sensual enjoyments. How can we express our concern and resentment, when we see how shamefully our species degrade themselves by that inordinate ambition, in particular, of aggrandizing themselves, and living in luxurious affluence, without shewing the least compassionate regard for the necessities of their fellow-creatures!

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